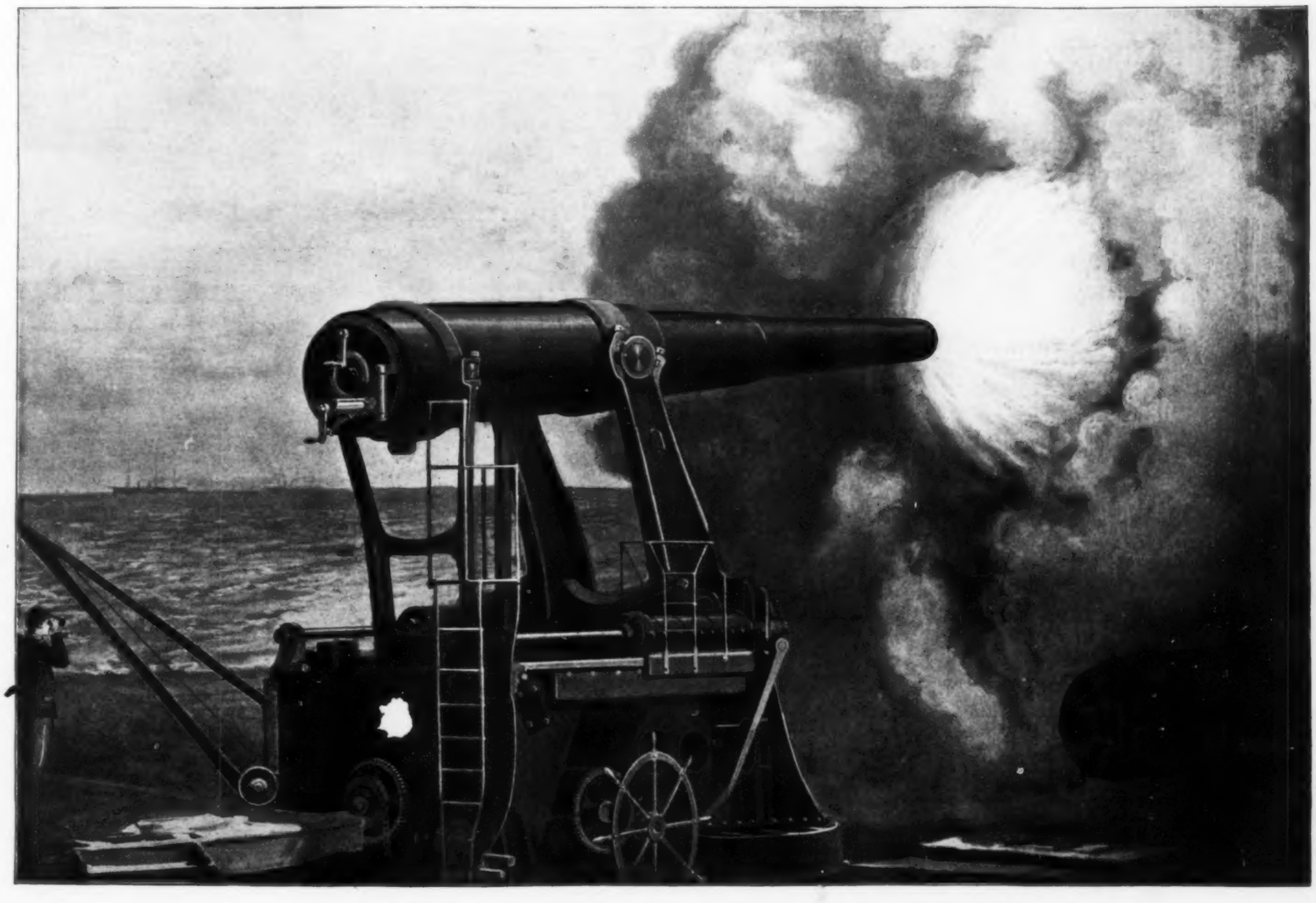
SCIENTIFIC AMERICAN

ARMY AND COAST DEFENCE SUPPLEMENT.



TEN-INCH BREECH-LOADING RIFLE ON A DISAPPEARING GUN CARRIAGE.
(FROM AN INSTANTANEOUS PHOTOGRAPH.)

GUNS, ARMOR, AND FORTIFICATIONS.

MUNN & CO., Publishers, 361 Broadway, New York.

WITH SUPPLEMENT SHOWING BATTLESHIP "IOWA."

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SCIENTIFIC AMERICAN COAST DEFENCE SUPPLEMENT.

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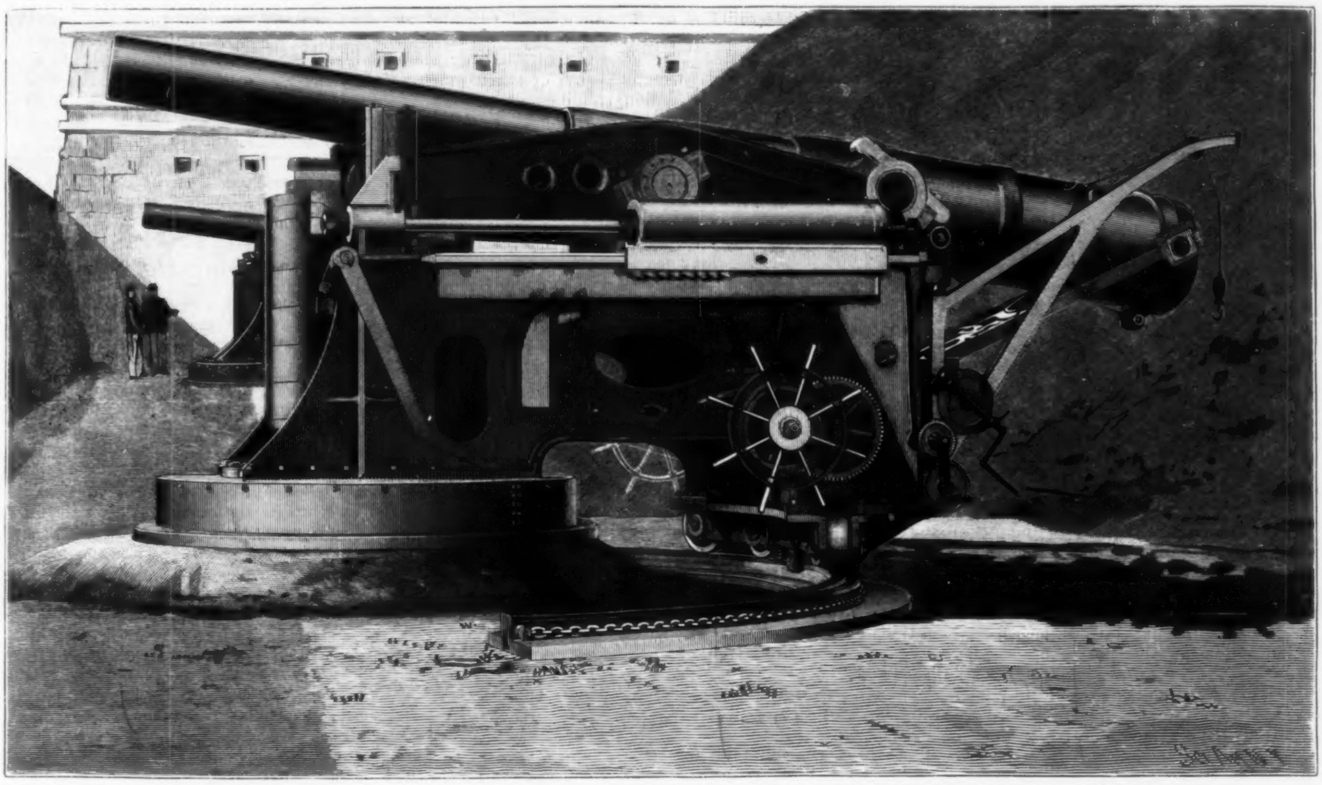
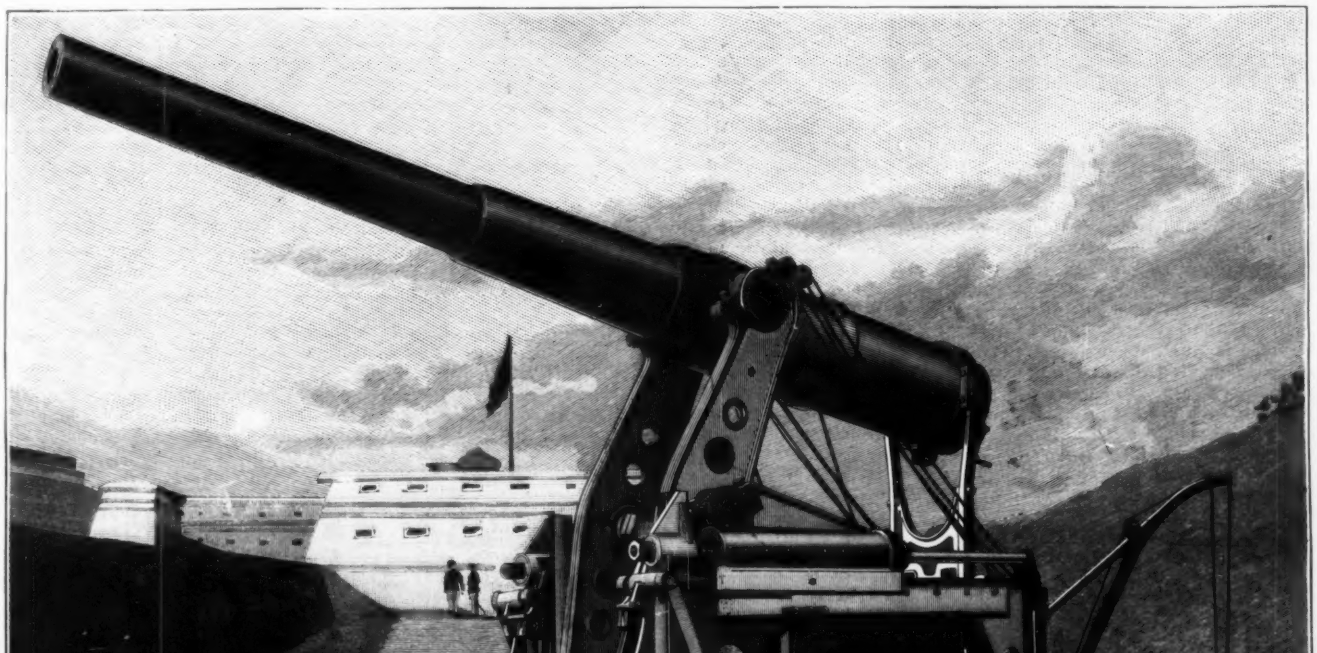


8-INCH GUN ON BUFFINGTON-CROZIER BARBETTE DISAPPEARING CARRIAGE, LOWERED FOR LOADING AND SIGHTING.



THE GUN, LOADED AND SIGHTED, RAISED ABOVE THE PARAPET FOR FIRING.

ARMY AND COAST DEFENCE EDITION
OF THE
Scientific American Supplement.

GUNS, ARMOR AND FORTIFICATIONS.

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INTRODUCTORY—THE TRUE LIMITS OF COAST DEFENCE.

THE term coast defence is one of the most elastic in the naval and military vocabulary. It is broad or restricted in its meaning, according to the policy adopted by the particular country that may be under consideration, and a wide diversity of opinion exists as to the exact extent of the field which it should cover. In its narrowest sense it refers to the system of signal stations, fortifications and submarine mines which guards the entrance to a country's ports and harbors and protects the seacoast cities against bombardment. In this case reliance is placed entirely upon fixed defences to resist the entrance of an enemy's fleet, and upon a standing army, assisted by a system of coastwise railways, to repel by quick concentration the landing of hostile troops. Such a scheme of coast defence abandons the sea entirely to the enemy; and by voluntarily giving up all the advantages to be obtained by the command of the sea it renders a country's borders conterminous with those of any foreign power that may possess a navy, however small. Indeed, a maritime nation, or a nation with a maritime frontier, if it fails to construct a navy, not only throws away the natural strength of its position, but leaves itself more open to attack than if it were entirely bounded by rival states. In the case of a people whose coast defence is literally confined to fortifications along its own coastline, the sea becomes a constant source of peril. It enables the enemy to attack, but effectually prevents any counter move against the invader in his own territory.

Although for the reason given it is not expedient to depend on shore defences alone, it would, of course, be possible to organize a powerful and even an impregnable system of coast defence that would depend entirely upon land fortifications, mines and a standing army; but to defend a long coastline so that every harbor should be impregnable against the strongest of fleets and every strategic point capable of a quick concentration of troops in numbers greater than could possibly be landed by an enemy, would be an enormously costly undertaking. There is no nation to-day that attempts it, and all systems of fortification include or act in conjunction with floating defences of more or less importance. The simplest form of these is the floating armored battery, which, when it is provided with motive power and is capable of independent maneuvering, is known as the harbor-defence monitor—a type that originated in this country and has always been extremely popular with the American people. The monitor is strictly a harbor defence vessel. The qualities of speed, seaworthiness and coal endurance which distinguish the seagoing battleship are sacrificed in favor of heavy armor and powerful guns. The draught is light, the deck is only a foot or so above the water, and the engine power is merely sufficient to enable the craft to maneuver readily in the presence of the enemy's ships. A few monitors constitute an invaluable addition to the harbor fortifications. They give a certain mobility to the defence and enable it to be strengthened at any particular part of the system which may be the object of a concentrated attack by the enemy's ships. Of equal or possibly greater importance than the monitor in co-operating with fixed defenses is the torpedo boat; for, while it is true that the rapid-fire gun has largely neutralized the offensive powers of these little craft, there is not the slightest question that the moral effect of the existence of a fleet of torpedo boats assembled for defence of a harbor will prove to be of incalculable value. The proper sphere of the monitor and torpedo boat lies within harbors, roadsteads and more or less sheltered waters, and a small fleet of these vessels co-operating with a powerful system of forts and submarine mines should render a harbor so impregnable that no hostile fleet, however numerous or powerful, would attempt its reduction.

It is certain, however, that the possession of a fleet of monitors and torpedo boats distributed among the various harbors would not enable a nation to do more than act purely on the defensive. Each seacoast city would be entirely dependent upon its own resources, for as long as a whole coastline was threatened by a hostile seagoing squadron, it would be necessary to keep the monitors and the torpedo boats on their allotted stations. The defence would be put to great disadvantage as compared with the attack, the enemy's force being concentrated in two or more divisions capable of uniting for a combined attack on any one position, whereas the defence would be divided between a number of widely separated points, any one of which would have to be equal to resisting the whole strength of the enemy.

Evidently the more economical method of defence is to supplement the land fortifications and the monitors and torpedo flotillas with a fleet of battleships capable of concentrating at any threatened point on the long line of coast defences. It was for this express purpose that our three powerful ships, the "Indiana," "Massachusetts" and "Oregon," were designed, and their special sphere of action is indicated by the name which they bear, or did formerly bear, in the naval register—"coast-defence battleships." As these vessels were not intended primarily to operate at any considerable distance from home coaling stations, they were given a limited coal capacity and a moderate speed. The weight that was saved in coal and engines was put into guns and armor, with the result that these ships carry heavier steel armor and more armor-piercing guns than the larger seagoing battleships which exist in foreign navies. The possession of a fleet of such ships enables the general scheme of coast defence to be carried out at far less cost than it could be if the fleet did not exist. The advantage of mobility is no longer altogether on the side of the invader. Not only can the defence be strengthened at any threatened point, but the moral effect of the mere existence of such a fleet in modifying the plans of the enemy and acting as a diversion is of incalculable advantage.

The next and perhaps the most important line of coast defence is a fleet of seagoing battleships, capable of going anywhere in any weather and carrying and even confining the conflict, if so desired, to the enemy's seaboard. The United States already possess one fine ship of this class, the "Iowa"; two others, the "Kentucky" and "Kearsarge," have been launched and are nearing completion; three others, the "Alabama," "Wisconsin" and "Illinois," are about half completed, the first named of the three being already afloat, while three others, not yet named, have recently been authorized.

From what has been said, it will be seen that the exact scope of the term coast defence will be determined by the policy adopted by any particular country. The first line of a country's defences may lie at its own immediate threshold or at that of the country with which it may be at war. Great Britain holds that the most effective way to defend its own coastline is to blockade that of the enemy. This policy she would be in a position to carry out because of the enormous fleet which she has built for the protection of her maritime trade.

The opposite extreme would be to act entirely within one's own seaboard and rely altogether upon coast fortifications for carrying on a defensive war.

It is questionable, however, whether, under modern conditions of warfare, it is possible for a nation to maintain successfully a purely defensive conflict; and while there may be something agreeable to the traditions of this country in such a policy, the events of the present war with Spain, as shown at Manila and elsewhere, have proved that an offensive defence is far more effective and in keeping with the temper and genius of the American people. Ever since the question of national defence was taken up there has been more or less division of opinion as to whether the protection of our coastline should be carried out upon the land or upon the sea, or upon both. Some have contended that a powerful navy, capable of meeting the enemy upon the high seas, was a sufficient protection; others have urged that a ship is costly and vulnerable, liable, indeed, by its complete destruction, to become a dead loss to the country. It is urged, on the other hand, that fortifications are more cheaply and quickly constructed than battleships and that if they are damaged they can be repaired at comparatively little cost.

The most effective system for this country is that which presents a threefold line of defence. First we need a fleet of battleships capable of keeping the sea in all weathers and provided with a large enough coal supply to enable them to operate, if occasion should call for it, at a great distance from the home coaling stations. The ships should have the same speed, and this should be at least equal to that which obtains in foreign navies. We have seen it recently stated by one of our leading warship builders that 15 or 16 knots is sufficient speed for any battleship, because no naval battle will be fought out with the ships moving at much over 12 knots. This may be true as regards the line of battle; but actual fighting is only one of the many duties of a fleet.

It is often as important to move quickly from point to point as it is to cast loose the guns and pour shell into the enemy. Sustained high speed for long distances is often demanded for strategetical reasons and will ever prove to be of incalculable value in the movements of a naval campaign, whether it be to make a dash upon a weak point in the enemy's defence, or to intercept or overtake his fleets, or to afford quick relief and protection at some unguarded point of attack on one's own coastline. In view of the fact that 18 and 18·75 knots is the contract speed called for or already achieved in many of the latest battleships of foreign navies, it is a question whether the contract speed of our future battleships should not be placed at a higher mark than 16 knots an hour. It is true that in actual service none of these foreign ships would reach or attempt to reach 18 or 18·75 knots, but it must also be remembered that a pro rata reduction must be expected and does actually occur in the case of our 16-knot battleships. If then the defence of our own coasts contemplates, as it undoubtedly should do, a certain amount of active operation off the coasts of the enemy, our seagoing fleet should possess a combined speed at least equal to that of any fleet that it may wish to bring to battle.

Undoubtedly the most effective system of defence for a powerful country such as ours is that which commences in the enemy's home waters. A fleet of half a dozen ships menacing his coastline will cause him to retain more than twice that number at home for the purposes of defence, and if the fleet happens to combine high speed and great coal endurance, the strength of the defending fleet must be proportionately increased. If we were at war with a first-class European power, half a dozen enlarged "Iowas" of 18 knots speed and great radius of action, threatening the enemy's seaboard, would effect more in diverting the enemy from our own coasts than twice that number of "Indianas" cruising off our home ports.

The second line of coast defence should lie within our own waters, and for this purpose ships of the "Indiana" class are the ideal fighting machines. Stationed at strategic points along the seaboard, a few small squadrons of such vessels, say two on the Atlantic, one in the Gulf and one on the Pacific, would be amply sufficient to cope with such battleships as a foreign power could spare from the defense of its own seaboard against our "flying squadron" of improved 18-knot "Iowas." Each coast defence squadron would have its swift cruisers and scouts spread out like a fan many hundreds of miles into the Atlantic, and in the ordinary course of events, an invading fleet would be sighted and reported in time enough to enable two or more of our coast defence squadrons to effect a junction and give battle on equal terms, if not with a positive superiority in fighting strength.

It may be urged that with a double line of defence in the shape of seagoing and coastline battleships it would be unnecessary to build any extensive system of coast fortifications. Indeed, there have not been wanting earnest advocates of a policy of floating defences, pure and simple, just as on the other hand it has been urged that ample protection may be afforded by the mines and fortifications without the assistance of a fleet. As a matter of fact, however, fortifications and fleets are the counterparts of each other, and the full value of each can only be realized when it is backed up by the co-operation of the other. This is a fundamental fact that should be clearly recognized, for nothing could be more pernicious than the idea that there is any competition or antagonism between the claims of the naval and army branches of coast defence.

As a matter of fact, the third or inner line of our seacoast defences has never received the measure of attention from Congress which its vital importance demands. The various appropriations of the past fifteen years have been devoted chiefly to the upbuilding of a new navy, and a gratifying amount of public enthusiasm has been aroused in the work of reconstruction. Unfortunately, in its efforts to create a navy, Congress has apparently failed to realize the importance of seacoast fortifications. While our navy has advanced with rapid strides, the work of building emplacements and mounting guns has followed with halting steps, and until the last two years the necessary annual appropriations have been doled out with a sparing hand. It is gratifying to note, however, that the country is now thoroughly awake to the importance of the subject, and there is reason to hope that the program of coast fortifications laid down by the Endicott Board many years ago will quickly be carried to completion.

In the SCIENTIFIC AMERICAN SPECIAL NAVY SUPPLEMENT we endeavored to place before the public a detailed account of our floating defences in the shape of battleships, cruisers, monitors and torpedo boats, and to create such a familiarity with the subject that our readers might easily recognize each ship as it was mentioned in the operations of the present war. The suggestion that we should bring out a special supplement on the subject of coast defence, which would deal in more detail with the subjects of armor and armament, has reached us from so many correspondents in various sections of the country, that we feel satisfied the demand for such a number is widespread.

In the present coast defence number we have en-

deavored to avoid going over old ground. Coast defence and naval operations, however, are so intimately related that in some few cases war material that is touched upon in the NAVAL SUPPLEMENT is again taken up for a more extended treatment, under the head of coast defence. In conclusion we would again impress upon the reader that the most effective coast defence is that which has its outposts at the enemy's seaboard, and as a reminder of this cardinal truth we present a double inset of our seagoing battleship "Iowa," which, with the ships of her type now building in our yards, must ever be regarded as forming the first line of the country's seaboard defences.

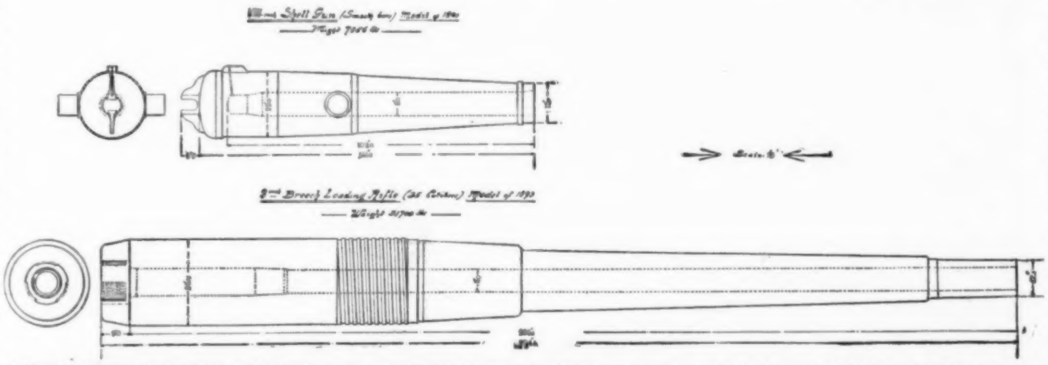
HEAVY BREECH-LOADING RIFLES.

THE heavy breech-loading rifle stands out as preeminently the weapon of coast defence. With its extreme carrying power of twelve miles and its ability to penetrate over twenty inches of steel at a closer range, it constitutes the chief agency upon which reliance is placed for preventing the entrance of hostile ships within our harbors, or the bombardment of our exposed seacoast cities.

Historical.

The manufacture of steel breech-loading guns in the United States commenced at about the time when we entered upon the work of building up a new navy. Previous to the year 1880, no steel guns had been constructed in this country, and the most powerful weapons in use at that time were "converted" cast iron guns provided with an inner rifled steel tube. The standard guns during the war of the Rebellion and the twenty years succeeding the war were the celebrated Rodman cast iron smoothbores, converted Rodmans, and the hooped Parrott rifles. Major Rodman's system produced the best results attainable with cast iron. It consisted in casting the guns hollow and cooling them from within, thereby modifying the initial strains and throwing the interior metal at the bore of the gun into a state of tension. This device, coupled with his work in producing slow-burning powders, has given to this American officer a high rank as one of the earliest and most successful experimentalists in the science and art of modern gun making. He did for our artillery what Ericsson did for the navy, and laid the foundation of the system upon which our modern breech-loading guns are constructed. While the European builders of ordnance carefully followed the traditional shapes and ornamentation of early times, the aim of Major Rodman was to determine the exact amount and location of the strains, and proportion and shape his weapons with sole reference thereto. He also paid particular attention to the selection and preparation of his gun-iron, and the result was a gun which, in its proportion of power to weight and in its endurance, was greatly superior to the weapons which were being turned out at the time in the gun factories of Europe.

In the course of his experimental work, Rodman caused two 8-inch guns to be cast from the same iron, one being cast solid in the usual manner, and the other being cast on a hollow core, through which a stream of water was passed while the metal was cooling. The iron was melted in two 7-ton furnaces, and after melting it was exposed in the furnaces to a fierce heat for sixty minutes. It was then run into a common reservoir, from which it issued in two streams, one of which led to each mould. The solid-cast gun was cooled in the usual way in an open pit. The hollow casting was cooled from the interior, by passing a stream of water through the core for a period of forty hours, when the core was withdrawn. The water was then allowed to flow through the bore of the gun for twenty hours. The mould for the water-cooled casting was placed in a covered pit, which had been previously heated to about 400 degrees, and this degree of heat was maintained as long as the stream of water was supplied. In the comparative tests the two guns were fired alternately up to the 85th round, when the solid-cast gun burst. The test was continued with the Rodman gun until it burst at the 251st round. The water-cooled gun thus showed an advantage of about 300 per cent over the common type. Many of the Rodman guns were subsequently converted to rifles by the insertion of an inner rifled tube. A gun of this type is shown on the following page.



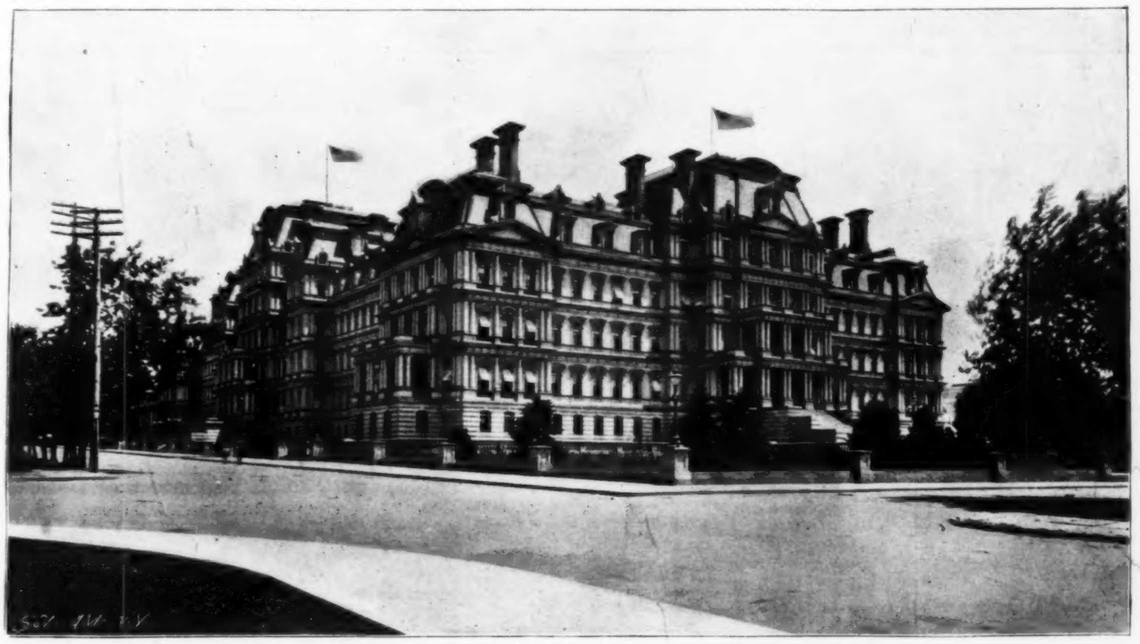
COMPARATIVE DIAGRAM SHOWING THE DIMENSIONS AND WEIGHT OF THE CAST-IRON SMOOTHBORE 8-INCH GUNS OF 1841 AND THE STEEL BREECH-LOADING 8-INCH RIFLES OF 1893.

The Parrott guns were cast iron weapons similar to the ordinary cast iron gun in shape, but somewhat lighter at the breech, where they were reinforced by shrinking on a wrought iron hoop. They were rifled, and fired a conical shot, but in point of durability they were inferior to the Rodman smoothbores. Indeed, the latter weapons are to-day the best representatives of cast iron ordnance in existence, and for the defense of channels and mine fields they would still prove to be serviceable weapons. Against the unarmored sides of modern cruisers, time-fuse shells from a 15-inch smoothbore would prove very effective, and a battery of these guns commanding a modern mine-field would prove a strong defence against countermining operations by the enemy.

It was in the period 1880 to 1883 that the Navy Bureau and the Ordnance Department undertook the manufacture of steel guns on modern lines. One of the first steps was to secure some two hundred tons of tempered and annealed steel forgings, for the purpose of making experiments designed to elucidate the principles of gun construction, and to determine the effect produced by oil treatment, annealing, etc., on forgings. We have already pointed out in the NAVY SUPPLEMENT that for two decades after the civil war we ceased to take any part in the development of war material, and that when we commenced the construction of a modern navy, we had to undertake the good work from the ground up, securing plans and suggestions for our earlier ships from foreign yards. The same stagnation, though perhaps not so pronounced, occurred in the army department; and when the government undertook the manufacture of modern steel guns, it very wisely determined to purchase its first material from those foreign firms which had been successfully engaged for many years in their manufacture.

For the first few years, the largest forgings used in American gun construction were secured from the Whitworth Company, in Manchester; but so rapid was the development of steel gun manufacture in this country, that it was not long before the government was able to depend entirely upon our domestic product. To-day the hooped guns of our army and navy are equal if not superior to any hooped guns that are turned out in the factories of the world.

The original Gun Factory Board recommended the creation of two separate establishments, one for the army at Watervliet, West Troy, New York, and the other at the Navy Yard, Washington. It was considered that with only one factory there would be an almost unavoidable conflict of authority between the two departments, and that their needs in many respects, particularly as to the gun-carriages, were so dissimilar that it would be the best economy to have two separate establishments, aside from the fact that the total productive capacity would be greater. The Washington gun factory, of which we present two views on pages 7 and 8, is devoted to the manufacture of naval guns, and the guns for seacoast defense are built at the Watervliet arsenal, an interior view of which is shown on page 6. The materials and process of manufacture are practically the same at both establishments, the chief points of difference being in the greater length of the seacoast guns, in the gun carriages, and in the breech mechanisms. As a rule, the army guns are longer, considerations of convenience and weight restricting the length of the guns carried by the navy.



STATE, WAR ARMY AND NAVY BUILDING AT WASHINGTON D. C.

Methods of Construction.

It can be readily understood that a special grade of steel is required to withstand the sudden and enormous strains to which a modern high-powered rifle is subjected. Gun steel has to be extremely hard to resist the severe blows to which it may be subjected from flying missiles; it must be able to withstand the friction of the steel projectile as it is shot through the bore, and the scoring action of the hot powder gases. It must also be both tough and elastic. All the gun steel used in our weapons is made by the Siemens open-hearth process, and it is treated by what is known as the Whitworth process of fluid compression. In this process the molten steel is poured into a strong cast-steel cylinder and subjected to heavy hydraulic pressure, by which the gas which is in the metal is squeezed out, and a greater density and higher quality given to the ingot, the cavities in the metal being completely closed up. After the ingot is cooled it is tested, re-

heated, and forged either under a steam hammer or in a powerful hydraulic press.

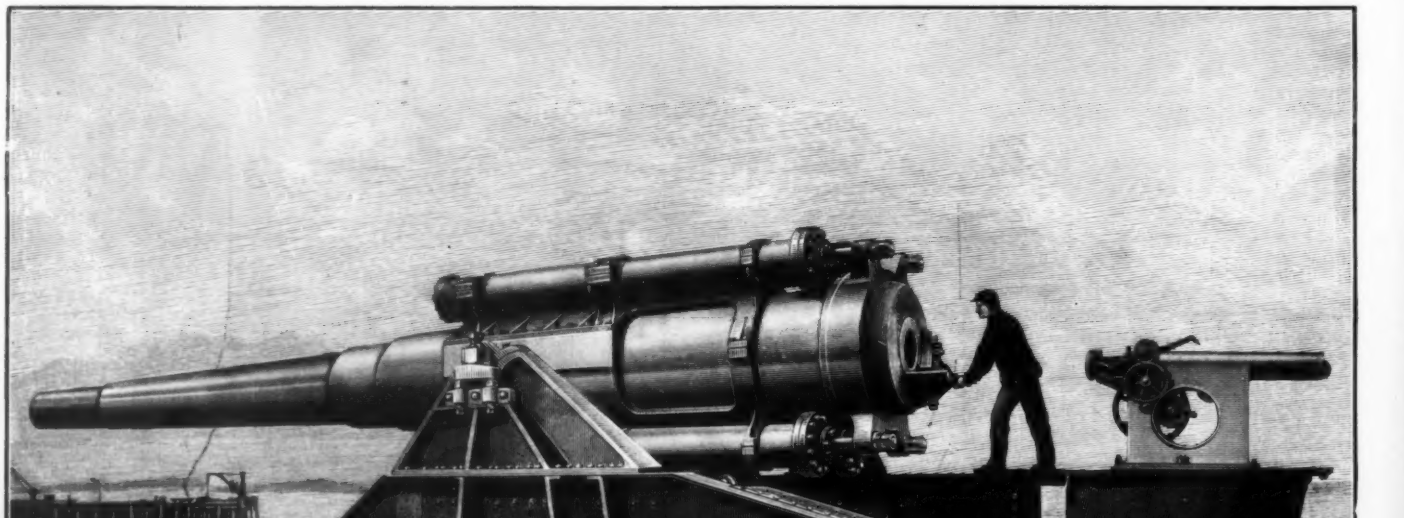
It would be well, just here, to refer to the sectional view of a 12-inch gun on page 5, from which it will be seen that a breech-loading rifle consists of an interior tube, a jacket in which it is inclosed for the greater part of its length, and a series of hoops inclosing the tube and the jacket. The arrangement of the hoops varies in the navy and army weapons. As compared with the army guns, it will be noticed, for instance, that the 13-inch navy gun shown in the comparative diagram, page 8, has only one set of hoops shrunk on over the jacket, and the chase hoops do not extend the full length of the "chase," or forward length of the gun.

The gun material, as it is prepared at the steel works and forwarded to the gun shops, consists of tubes and hoops of various lengths and diameters. They are prepared by reheating the ingot, boring it, and then drawing it out on a mandrel under a forging press or a steam hammer. They are next annealed in order to remove any strains that may have been set up by the forging. This is done by placing the forgings in a special furnace, raising them to a predetermined temperature, and then allowing them to cool slowly. By this means the steel is softened, and all internal strains are allowed to work off. The forgings are next bored and turned down nearly to the finished size. The material is then oil-tempered to give the necessary toughness to the steel. In this process it is slowly heated and then lifted out of the furnace and lowered into a bath of oil, while if it is a tube or jacket a current of oil is made to flow through the interior. The steel cools very slowly, owing to the fact that oil is a poor conductor of heat, and the molecules of the steel have time to readjust themselves. The result is that the elastic limit and the ultimate tensile strength of the steel are greatly increased. The forgings are once more annealed, and specimens are cut from each piece and tested. This work is carried out under the strict supervision of officers of the Ordnance Department and the greatest care is taken to see that the quality of the forgings, whether they are for tube, hoops, jacket, breech or muzzle, is perfectly unvarying. It is required that the forgings as they are delivered by the private manufacturers to the government arsenals, must show an elastic limit of from 46,000 to 50,000 pounds to the square inch, and an ultimate tensile strength of from 86,000 to 93,000 pounds to the square inch. That is to say, a specimen must be capable of the deformation due to a strain of from 46,000 to 50,000 pounds to the square inch without showing any permanent "set," and it must endure a pull of 86,000 to 93,000 pounds to the square inch before absolute rupture takes place. Moreover, it must show an elongation or stretch at the time of rupture of 15 to 17 per cent in a length of 3 inches.

8-INCH CONVERTED RIFLE—ORIGINALLY A 10-INCH CAST-IRON RODMAN SMOOTHBORE OF THE TYPE USED DURING THE REBELLION. PENETRATION OF RIFLE, 7·42 INCHES AT 1,000 YARDS.

Theory of the Built-up Gun.

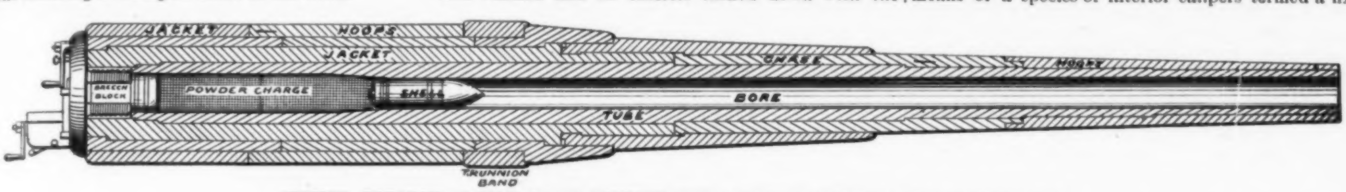
Before passing on to a description of the machining and assembling of the guns in the government gun shops, we will consider briefly the theories upon which the hooped or built-up guns are constructed. If the metal of which a gun is constructed were perfectly inelastic, the pressure of the powder in the bore at the moment of explosion would be instantly felt and resisted throughout the whole thickness of the gun from bore to circumference. But steel is very elastic, it gives under stress; and since at the moment of firing the work of resisting the pressure falls immediately upon the layer of metal next the bore, it is probable that this interior metal will be stretched beyond its limit of endurance and ruptured before the outer layers of metal are taking their full share of the stress. As we have already pointed out, Rodman met the difficulty by cooling his guns, at the time of casting, from the interior, thereby causing the outer metal to shrink onto the inner and throw the whole gun into a state of initial strain, the metal near the bore being in compression and the outer metal in tension. With the introduction of of steel guns the same excellent principle was followed, although, for the sake of securing a better quality of steel, due to the forging, annealing and tempering processes, already mentioned, the steel guns were not made in one casting, but were built up of a central tube upon which were shrunk a series of hoops. The effect is the same that Rodman achieved, but it is much more scientifically arrived at, and, of course, the material employed is of a far stronger and more durable and reliable quality. In the finished hooped gun the tube is in compression and the hoops are in tension. Consequently, when the gun is discharged, the



IMPROVED PATTERN OF 13-INCH NAVAL GUN—TO BE MOUNTED ON OUR LATEST BATTLESHIPS.

Weight, 145,000 pounds; **weight of shell**, 1,100 pounds; **weight of charge**, 550 pounds; **muzzle velocity**, 2,100 feet per second; **muzzle penetration**, 27 inches of steel; **rate of fire**, one round in 1 minute 47 seconds.

pressure is felt and resisted instantaneously throughout the whole thickness of the gun, every particle of metal assisting in doing its share of the work.



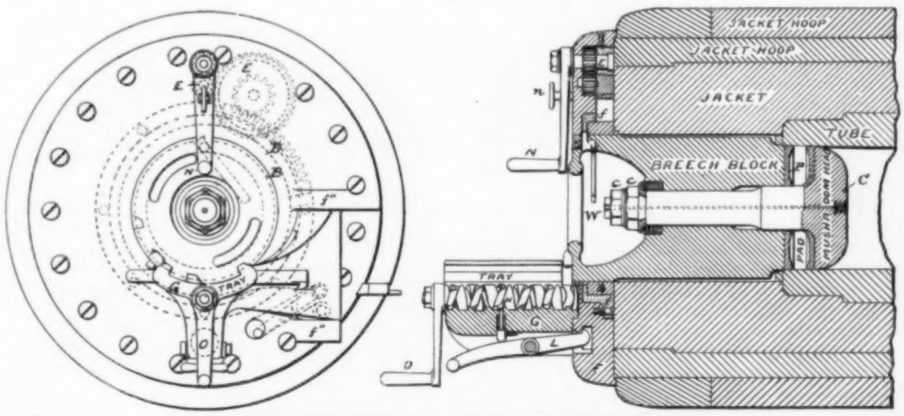
SECTION THROUGH 12-INCH COAST DEFENCE GUN, SHOWING METHOD OF CONSTRUCTION.

Assembling the Gun.

The foundation upon which the gun is built up is the "tube," and the first operation at the gun-shop is to center it in the lathe, since it may have been warped in the process of oil tempering, and bore it, there being perhaps as much as half an inch of metal to be removed during the boring operation. The finish reamings are given with a reamer consisting of a stock whose head carries a block of hard wood soaked in oil, turned to shape and provided with steel cutters. By these tools the bore of the gun is perfected. Before the final finish reaming, the tube is turned on the outside.

In this operation the gun is supported at some intermediate point with steady-rests, for whose bearing seats are turned upon the exterior of the gun. The surface is first rough-turned to within about 0·03 of an inch of the shrinkage diameter. The final turning is given with a square-nosed tool about an inch in width, and here the utmost accuracy must be observed, no variation exceeding 0·003 of an inch being tolerated. Over the inner tube is shrunk a heavy tube which is termed a jacket, and a number of other tubes superimposed and rabbeted at the ends, termed hoops. Each one of these is prepared on the same lines as just described for the tube, each one being accurately bored and reamed and its exterior turned down with the greatest exactness. For hoops and jacket the general principle is followed that boring and finishing the interior surfaces precedes the final turning of the exterior or shrinkage surfaces.

The hoops and jacket are a little less in interior diameter than the exterior diameter of the cylinder which they are to embrace, about a hundredth of an inch shrinkage per linear foot of diameter being allowed. To put a hoop in place, the part destined to receive it, which may be the interior tube or may be the partially hooped gun, is set up on end in a special centering-pit near the furnaces. The hoop is heated in a furnace, whose fuel is raw petroleum, actuated by a blast. As the piece gets hot its diameter is constantly tested by means of a species of interior calipers termed a fixed star gage. As soon as it has become large enough it is lifted out of the furnace and lowered into place over the vertically supported gun.

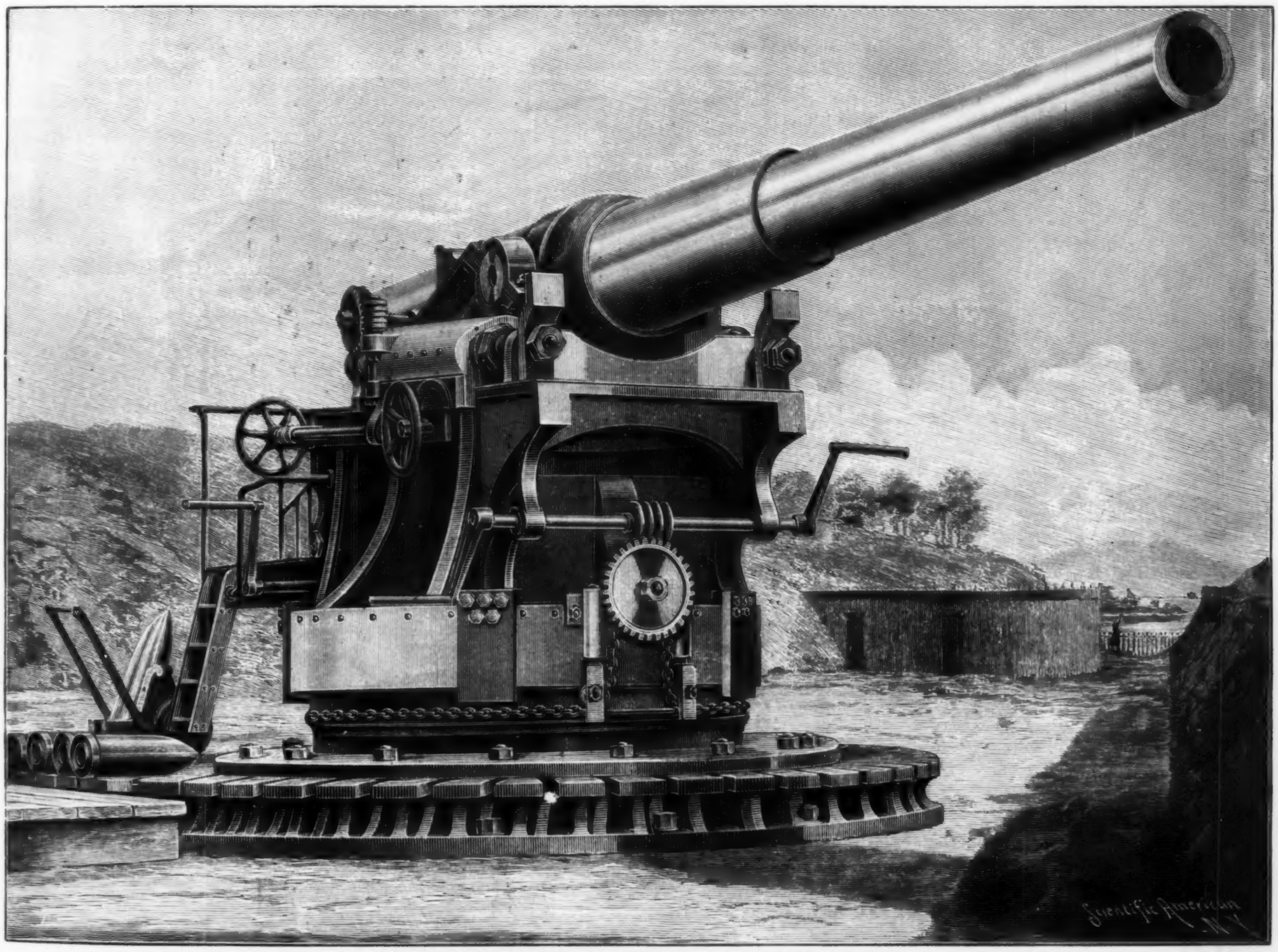


BREECH MECHANISM OF 12-INCH COAST DEFENCE GUN.

The gun is again put in the lathe chuck, and supported by steady rests and prepared for a new hoop. In this way it is gradually built up. It is to be observed that the shrinkage surfaces are left as they come from the square-nosed tool in the lathe. They are not touched with the file or emery paper. The shrinkage operations slightly diminish the bore, indicating what a tremendous power is exerted by the hoops, and necessitating a final finish reaming of the bore before rifling.

When all the hoops are in place, the exterior of the gun is turned in the lathe to its final shape, and then it is gone over from one end to the other with files in the hands of the workmen as it turns in the lathe, so that its exterior surface leaves the shop as perfectly hand-finished as any piece of fine machinery.

The interior has to be bored and reamed out to provide an enlarged powder chamber at the breech end. In the 12-inch gun this is about 6 feet long and about 2 inches larger in diameter than the bore of the gun. Then a conical slope 18 inches long comes between the



12-INCH COAST DEFENCE GUN MOUNTED ON BARBETTE CARRIAGE.

Weight, 128,719 pounds; **weight of shell,** 1,000 pounds; **weight of charge,** 487 pounds; **muzzle velocity,** 2,100 feet per second; **penetration at the muzzle,** 27·1 inches steel; **rate of fire,** ten rounds in 28 minutes 11 seconds.

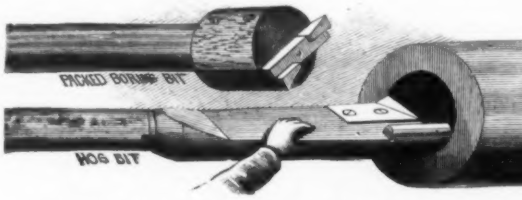
forward end of the powder chamber and the bore of the gun. This is not all. To enable a projectile to enter the bore, and for its packing rings to fill the grooves, what is termed the forcing slope must be bored out. This consists, in the case of the 12-inch gun, in a slight enlargement of the bore, with a very slight taper, at the breech end, for a distance of some 4 feet. This increases the bore at the rear end of the forcing slope a little over 0·05 of an inch, the enlargement reducing, of course, to zero at the forward end.

The next operation is the rifling of the bore. In order to give the proper rotation to the projectile, the bore of the gun is cut, from the powder chamber to the muzzle, with a large number of shallow spiral grooves, 72 of these being used in the 12-inch gun. The grooves start parallel to the axis at the rear of the bore and then are given an increasing twist up to the muzzle, where they have a twist of one turn in twenty-five diameters.

The Breech Mechanism.

By reference to the sectional drawings, page 5, it will be seen that the jacket overlaps and extends to the rear of the tube, and forms what is known as the "screw-box," which receives the "breech-block," by which the breech is closed after loading the gun. A deep thread is cut on both the block and the box, a sufficient area of thread being provided to withstand the pressure tending to blow out the block, a pressure which is, of course, exactly equal to that which drives the projectile from the gun. As it would take a long time to screw the plug into its place if it were rotated the dozen or more times that would be necessary if the thread were left intact, the thread in both breech-block and box is "interrupted," that is to say, four equal channels are cut across it parallel to the axis, the width of the channels being equal to the width of the remaining thread. Now, by bringing the threaded portions on the breech-block opposite the channels in the screw-box, the block may be pushed home into place. Then, by giving the block one-eighth of a turn, the remaining thread on the block will be brought into engagement with the remaining thread in the box and the breech "locked." Although the breech-block is very accurately made, it does not fit closely enough to prevent the escape of the powder gases. This is accomplished by means of an automatic "obturator," known as the "mushroom." This is a piece of metal, C (see page 5), with a mushroom-shaped head and a stalk which slides through the breech-plug, and is held in place by the nuts, c c. Back of the head, and between it and the end of the breech-plug, is a pad, P, made up of asbestos and tallow contained in a canvas ring. When the gun is fired the pressure squeezes the pad between the mushroom and the plug and forces it out to a tight fit against the chamber of the gun, thus forming a perfect gas seal. The spindle or stalk is perforated to provide the vent through which the charge is ignited by a primer, which is screwed into the rear end of the stalk at W each time that the gun is fired.

The rear end of the block carries a rotating ring, B, provided with a gear arm, D, for locking or unlocking the block. This is accomplished by means of a crank N, and the gears, E, E. After the block has been given one-eighth of a turn, it is withdrawn onto the "tray," G, by means of the crank, O, and the "translating screw," H. The tray is hinged to the lugs, f', on the gun, and after the block has been drawn out, both are swung around, leaving the breech clear for the next loading. The "translating screw" is cut with a double thread, one right-handed and the other left-handed. The right-handed thread engages a thread cut through the tray, and the left-handed thread engages a stud projecting downwardly from the end of the breech-plug. When the crank, O, is turned, the screw, H, moves to the rear in the tray and the breech-block moves to the rear over the translating screw. Hence the rotation of the screw withdraws the breech-block from the box with a movement equal to the sum of the pitches of the two threads for each revolution of the screw, thus greatly expediting the movement. The crank, N, and the arm, D, are locked in place by the small spring catch, n, and the tray, G, is similarly held in position by the latch, L.



BORING TOOLS FOR HEAVY BREECH-LOADING RIFLES.

The guns are fitted with their breech-mechanism in a small knock-down shop as shown in our illustration on the eighth page. It would be a slow and troublesome task to transfer these heavy weapons, weighing some 50 tons apiece, to a common breech-mechanism shop, and to avoid this the guns are run out of the shops on a car in pairs, and blocked up in any convenient position in the yard with their breeches facing each other. The portable shop is then erected over them, and the work of assembling the breech-mechanism is carried out under its shelter.

The complete operations of loading a 12-inch sea-coast gun during a series of rounds are as follows: The catch, n, is released and the breech-block rotated one-eighth of a turn by the crank, N. It is then drawn onto the tray by turning the crank, O, and swung clear of the breech. The gun is "sponged" by pushing a swab through the bore, and the shell, weighing 1,000 pounds, is then wheeled up to the breech on an adjustable tray, and pushed home with a swift thrust until it is brought up by the copper rifling-band bringing up against the rifling in the bore. The powder charge, weighing 487 pounds, is next lifted into the powder chamber and pushed home close to the base of the shell. The tray is then swung round to the rear of the breech-box, the plug slid into place and locked; a primer, with a lanyard (cord) attached, is screwed into the outer end of the mushroom stalk, and the gun is ready for the command, "Fire!"

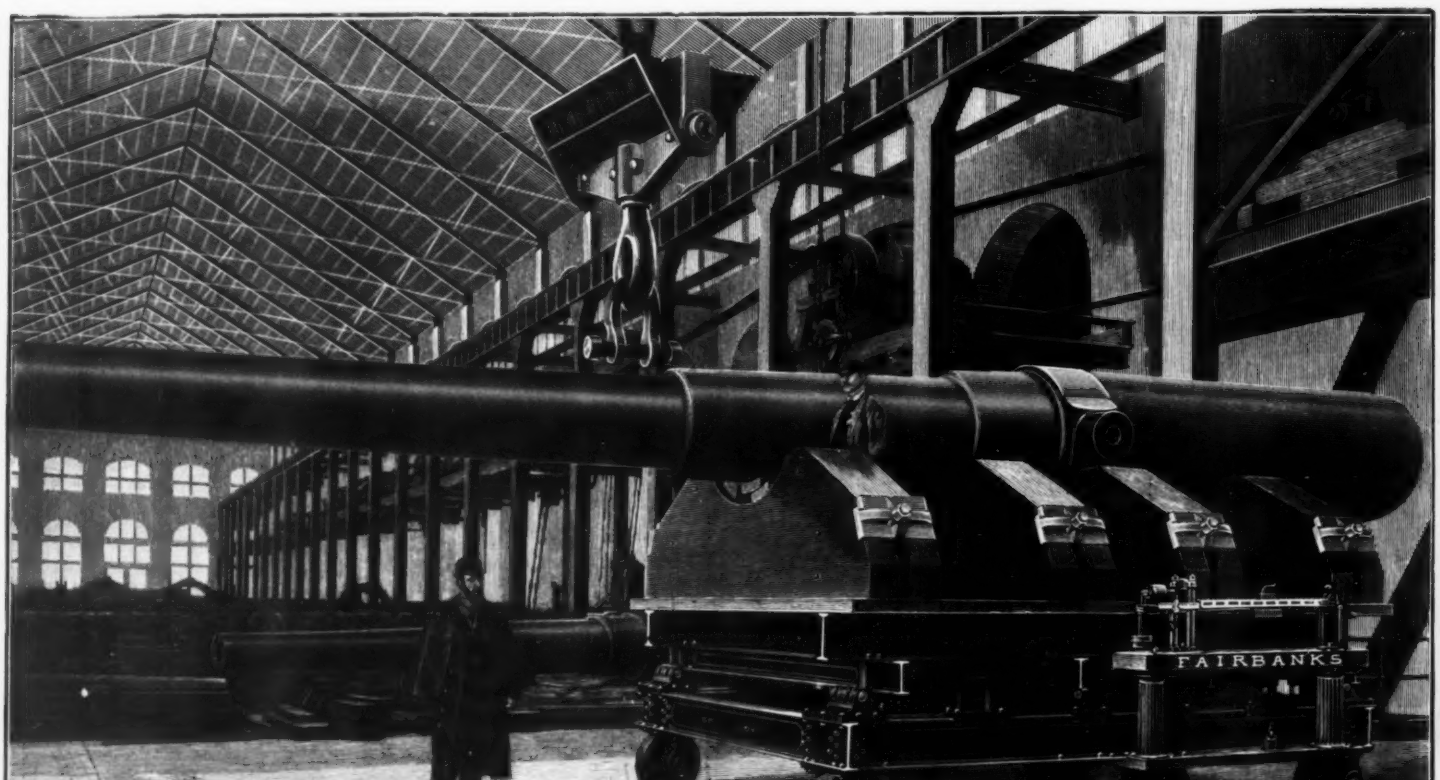
The 12-inch gun shown on pages 5 and 6 is 40 feet long and weighs 64½ tons. The bore is 37·8 feet long, and the outside diameter of the gun over the powder chamber is 46·4 inches. When the gun is fired, a pressure is produced on the walls of the powder chamber of 19 tons to the square inch. The shell leaves the gun with a velocity of 2,100 feet per second, and its energy is 30,570 foot-tons, that is to say, it would be capable, if gradually applied, of lifting the Spanish cruiser "Vizcaya" bodily 4 feet into the air. If the shell struck the "Vizcaya" squarely at a range of 1,000 yards, it would be capable of penetrating both 12-inch steel belts, and passing entirely through the vessel. This, however, is not what our artillerists aim to do. The shells are fitted with a "delay" fuse which will explode them within the vessel just after they have passed through the armor. The question of projectiles, however, will be dealt with in a later chapter.

The comparative diagram, page 8, is presented to give the reader a graphic view of the relative sizes of our breech-loading guns, from the 3·2-inch field-gun up to the great 16-inch gun for coast defense, which is now nearing completion. It must be understood, however, that the diagram does not include all the guns employed in the two services.

The Naval 13-inch Gun.

The 13-inch gun is the largest gun at present in use in the navy, and the weapon shown in the diagram is the same as forms the main battery of the "Indiana," "Massachusetts," and "Oregon." The 13-inch gun shown in the engraving, page 4, is similar to that shown in the diagram in the construction of its tube, jacket, and hooping, but it is provided with a new type of mount, designed by Lieut. Fletcher, of the United States navy, which, in connection with the excellent breech-mechanism designed by the same officer, has given to the 13-inch gun many of the advantages of the rapid-fire gun, and has reduced the time of loading and firing nearly 50 per cent.

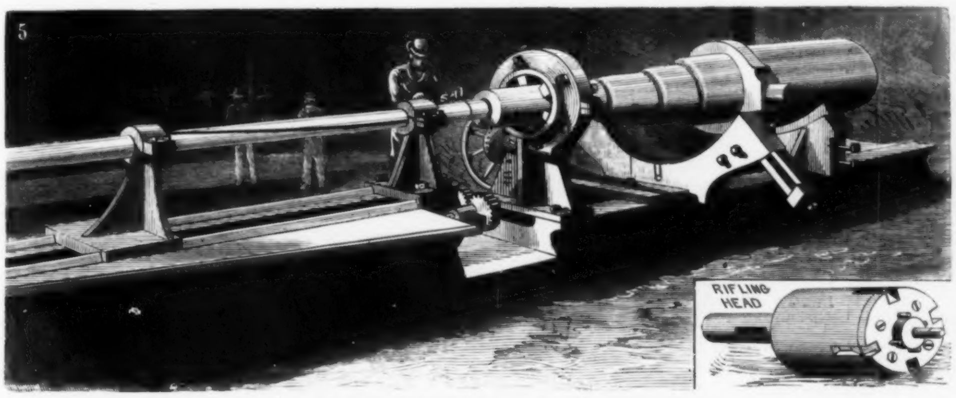
The breech-block of the 13-inch gun has six equal channels cut through the thread, as against four channels on the 12-inch army gun, and hence it is only necessary to give it one-twelfth of a turn as against one-



WEIGHING A 52-TON GUN ON THE 150-TON GUN SCALE AT THE WATERVLIET ARSENAL.

eighth in the other weapon. It will be remembered that in the 12-inch breech-mechanism there are three distinct operations to be performed in opening the breech. It is rotated by one crank, withdrawn by another, and then pulled around clear of the breech. In the Fletcher mechanism all three operations are performed by the continuous rotation of a single crank at the side of the breech. The construction is as follows: A stout bracket is bolted to the side of the gun at the breech, which carries a crank and shaft, at the inner end of which is a worm. The worm engages a worm-wheel at the top of the hinge-shaft on which the plug-tray swings. Just below the worm-wheel and keyed to the same shaft is another wheel, which, in the first period of the rotation of the vertical shaft, acts as a worm-wheel on a circular worm-rack on the breech-block to rotate the block, and then acts as a gear wheel on a horizontal rack attached to the side of the block and slides it out of the screw-box onto the tray. As soon as the block is on the tray, the continued turning of the hand-crank swings the block and tray clear of the breech. The simplicity and ease of handling of the mechanism has greatly reduced the time of loading these heavy weapons, as may be judged from the fact that in an official test of a 13-inch gun the breech was opened in 8·72 seconds, and all the operations of opening breech, loading, and firing were executed in 1 minute and 47 seconds. The gun is carried in a massive sleeve, which is pivoted to the plate-steel revolving gun-carriage, shown in the engraving. When the gun is fired it slides within the sleeve, its motion being controlled by four recoil cylinders, which are mounted on the sleeve, two above and two below it. The cylinder piston rods are attached to a massive ring which is shrunk on the breech of the gun. When the gun recoils, the pistons travel with the gun, the cylinders remaining stationary on the sleeve.

The recoil of the gun is controlled by a series of heavy coil springs at the back of the pistons, aided by the resistance of a mixture of glycerine and water which flows past the pistons through a series of grooves cut in the walls of the cylinders. The grooves allow the fluid to flow freely at first, but they are so cut that the openings are gradually throttled as the pistons advance, thus presenting an increasing resistance which gradually brings the gun to rest. Although the initial energy of recoil is about 34,000 foot-tons, the great gun is brought up within the space of forty inches. Glycerine and water are drawn in after the pistons during the recoil and are shut in by a valve when the recoil is completed. When the valve is gradually opened, the coil springs slowly force the gun forward to its original position in the sleeve.



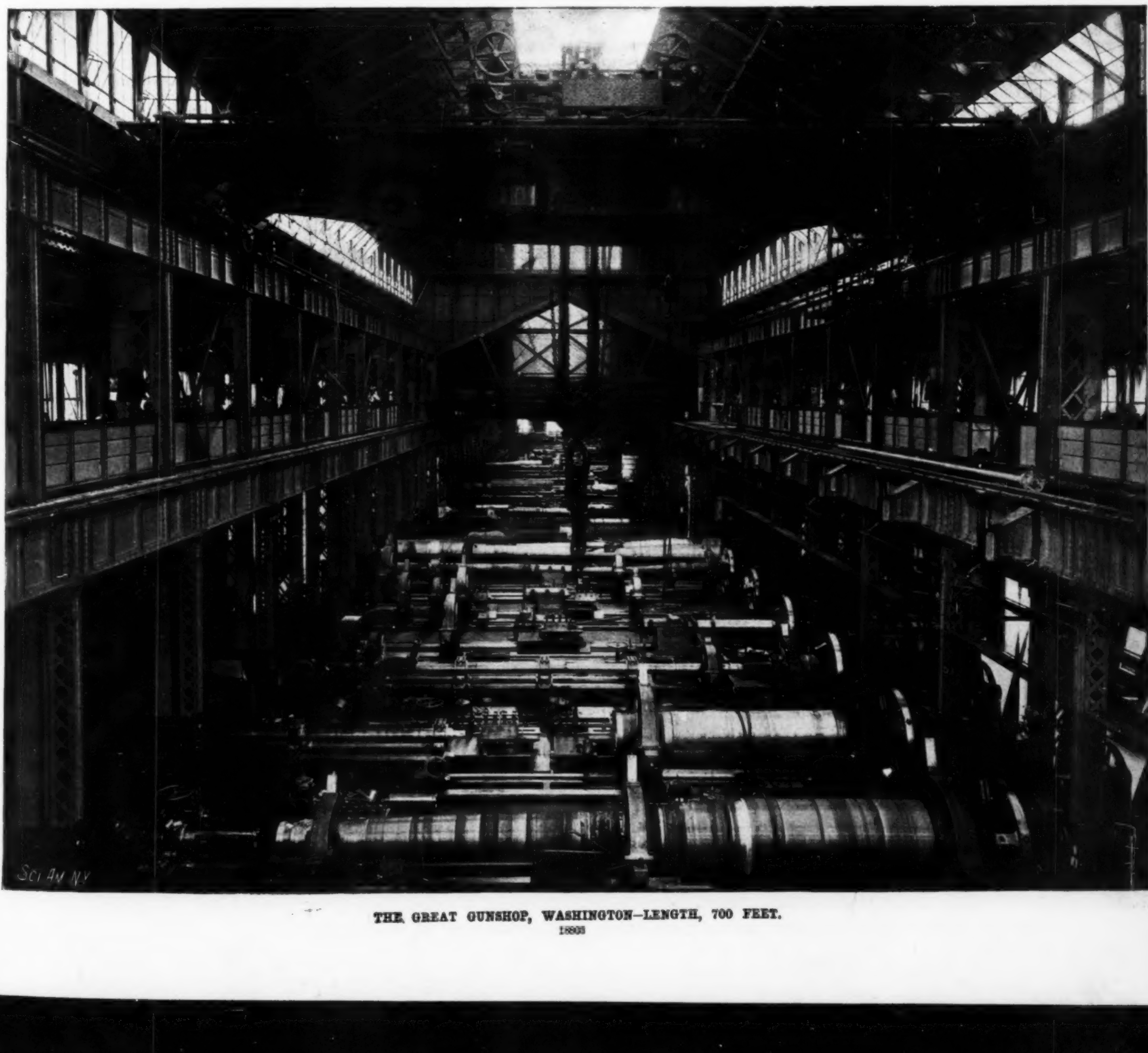
MACHINE FOR RIFLING HEAVY GUNS.

Seacoast Gun Carriages.

The army guns for seacoast defense are all provided with heavy trunnions. The 12-inch gun, shown on page 5, is mounted on a barbette carriage, and the trunnion sleeve, which we have just described in the 13-inch navy gun, is replaced by a massive top carriage, in the bushed bearings of which rest the two trunnions of the gun. The top carriage is formed in one piece with two recoil cylinders, one on each side of the gun. The carriage rests upon rollers of forged steel, which, as the gun recoils, enable it to travel over the under carriage. The cylinders travel with the upper carriage and the pistons remain stationary, being attached to the under carriage. The action of the recoil is similar to that already described in connection with the navy gun.

The gun is elevated and depressed by means of the vertical worm and worm-wheel seen on the right-hand side of the gun to the rear of the recoil cylinders, the worm-wheel in turn operating a pinion which engages a circular rack attached to the gun. The whole gun-carriage is mounted upon a circle of steel rollers, and the gun is turned to the right or left (traversed) by means of a chain which is carried around the base of the carriage and fastened to the stationary foundation-plate. This chain passes up and over a sheave which is operated by two hand-cranks through a worm and worm-wheel. This traversing gear is seen in the illustration in the front of the carriage beneath the chase of the gun.

The heavy seacoast guns of 8, 10 and 12-inch caliber are mounted either on barbette, disappearing or casemate carriages. The gun herewith illustrated is of the first type. It fires over a parapet and is permanently exposed to the fire of the enemy. The disappearing gun is loaded and sighted in the lowered position (see first page illustration), the gun and gun-crew being



THE GREAT GUNSHOP, WASHINGTON—LENGTH, 700 FEET.

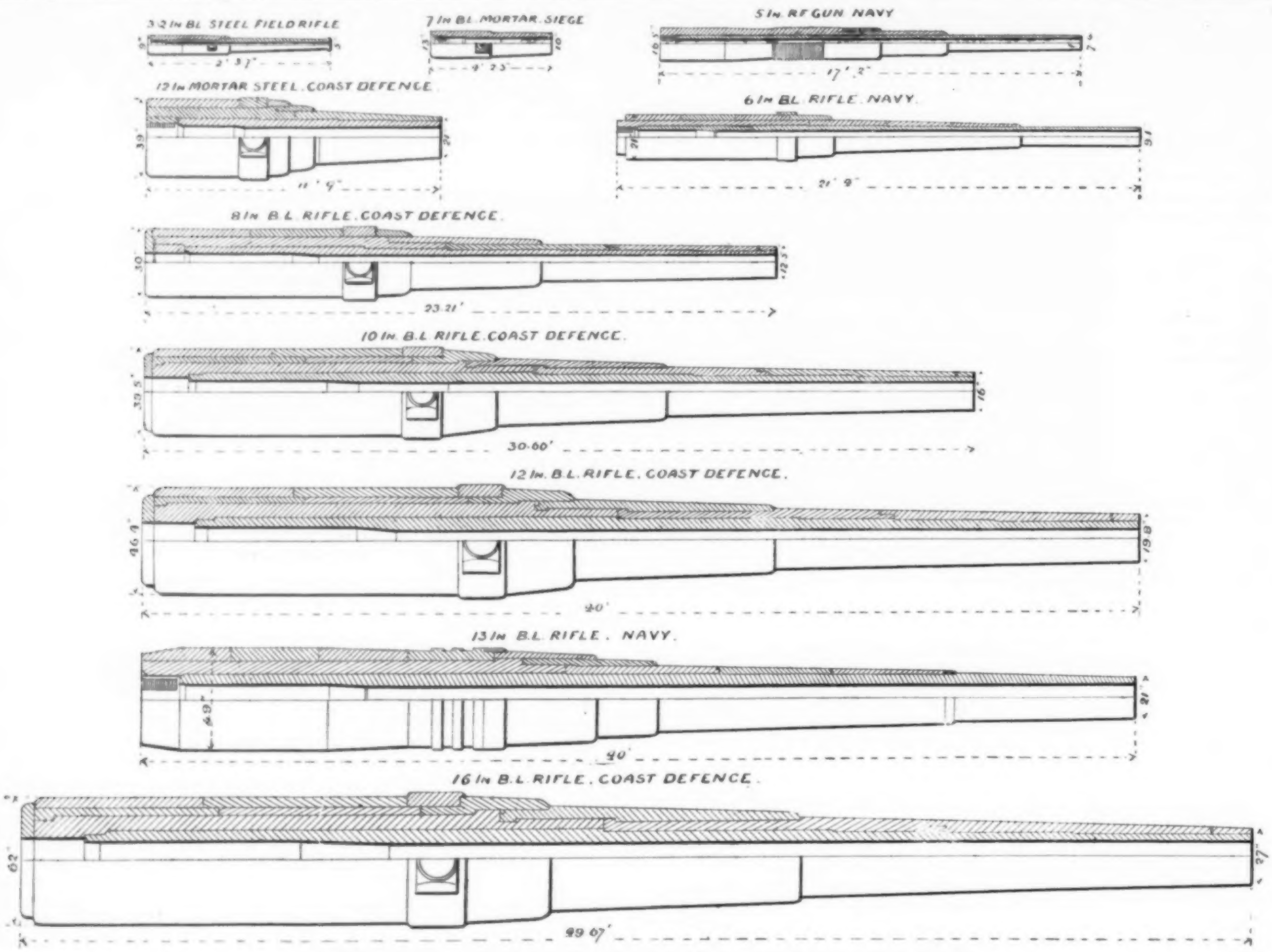
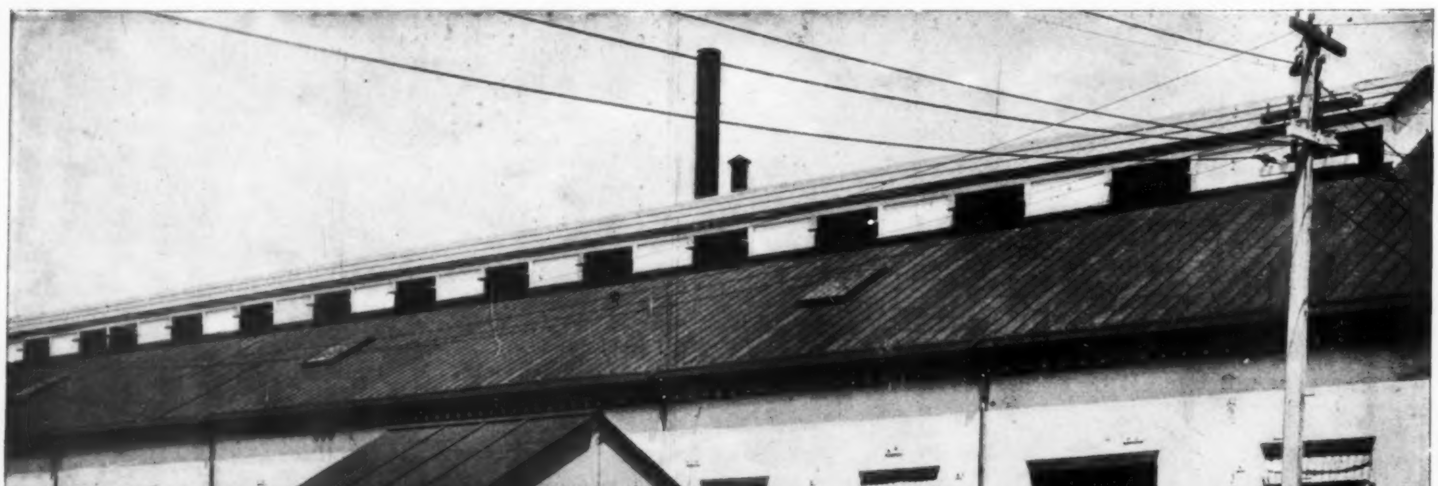


DIAGRAM TO SCALE SHOWING RELATIVE SIZES OF ARMY AND NAVY GUNS.

below the parapet and out of sight of the enemy, and it comes into view above the parapet for a few seconds only at the moment of firing—the recoil serving to throw it back and down to the loading position. The casemate carriage is somewhat similar to the barbette carriage, but it has a much smaller arc of training, and fires through a port casemate instead of over a parapet. The most successful disappearing carriage in this country, and probably in the world, is that designed by Colonel A. R. Buffington and Captain William Crozier, of the United States army. Two engravings of this carriage appear on our first page, and a full description will be found on another page under the head of "Disappearing Gun Carriages."

Rapidity of Fire of Heavy Breech-loading Rifles.

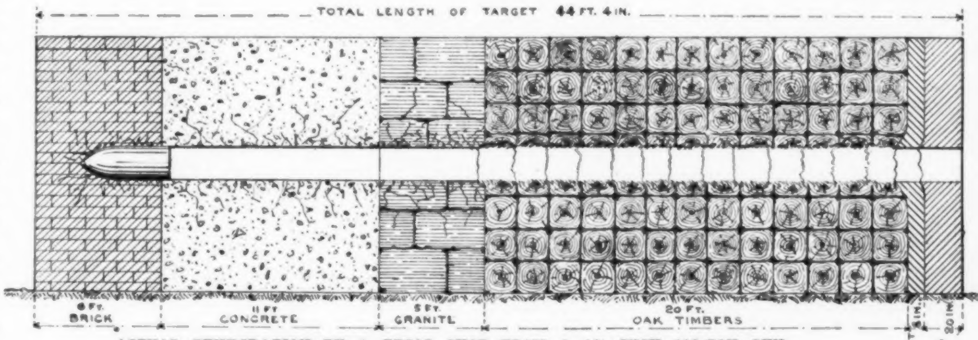
One of the questions most frequently asked by the general public regarding our big breech loading rifles is how quickly can they be loaded and fired. A test of this very point was recently carried out by the Ordnance Board on the 8, 10 and 12-inch rifles. Ten rounds were fired from a gun of each type. The test commenced with the breech-block closed, the gun at the proper elevation for loading, and a shot lying ready near the breech in the loading-tray. The command



PORTABLE SHOP FOR ASSEMBLING BREECH-MECHANISM OF HEAVY GUNS.

"Load" was given, and the operations of loading and firing were continued without intermission until the discharge of the tenth round. The results were as follows: Eight-inch rifle, served by a detachment of 12 men, 10 rounds in 17 minutes. The board considered that under normal conditions this time would be reduced to 14 minutes. Ten-inch rifle, served by a detachment of 14 men, 10 rounds in 14 minutes 39 seconds. Twelve-inch rifle, served by 17 men, 10 rounds in 28 minutes 11 seconds.

Good as this record is, it could be bettered by the adoption of the improved naval breech-mechanism of which we have given a description above, and also by the substitution of mechanical for hand power in bringing the ammunition from the magazines to the gun-platform and in training and elevating the gun. The navy, as we showed in the NAVY SUPPLEMENT, is fully equipped with mechanical devices for these purposes, the work being accomplished either by hydraulic power, steam, compressed air or electricity; but at present hand power predominates in the manipulation of our seacoast guns. There are no structural difficulties in the way of installing mechanical power in our batteries, and its use, particularly in the matter of bringing the heavy ammunition from the magazines to the gun platforms, would vastly increase their efficiency.



ACTUAL PENETRATION BY A TRIAL SHOT FROM A 16¼ INCH 110-TON GUN.

These seacoast guns are among the most perfect weapons of their kind in the world, and it is sincerely to be hoped that in the new era of progress, that will result from the lessons of the present war, we shall see the handling facilities and general equipment of our coast defence batteries brought fully up to the level of that installed in our navy.

The Great 16-inch 125-ton Coast Defence Gun.

Before closing our chapter on the breech-loading rifles, mention must be made of the great 16-inch gun which is now nearing completion. With the comparative failure, some years ago, of the 16¼-inch 110-ton guns and the 17-inch 105-ton guns, respectively mounted in the English and Italian navies, the manufacture of these monster weapons ceased altogether, and it was predicted at the time that no more of them would be built. The tendency of late years has been to reduce the weight of the main battery, the heaviest guns of the United States battleships being of 64¾ tons weight; of the English, 46 tons; of the German, 43 tons; and of the French, 44 tons. The reasons which led to the adoption of the lighter guns were the great difficulty of manufacturing guns of over 100 tons weight that would stand the actual test of firing; their destructive racking effect upon the ships in which they were mounted; the large amount of weight which had to be allotted to their mounts and protection, and the slowness of their discharge. It was found, moreover, that by increasing the length of the guns, reducing the caliber, and using smokeless powder, a much greater speed of firing and an equal amount of penetration could be obtained for about half the total weight of guns and mounts.

But, while the argument in favor of lighter and more handy guns is a powerful one, as applied to battleships, it is not so strong as applied to land fortifications. The mounting and protection of a gun of over 100 tons weight in an earth and concrete emplacement costs far less than it does to place the same gun with equal protection upon a battleship. The unsteady platform afforded by a ship's deck, combined with the slowness of firing so huge a weapon, makes the probability of scoring a hit very remote; but such a gun mounted in a fort and trained across a channel, such as the entrance to New York Bay or San Francisco Harbor, where the ranges are moderate and accurately known, would have every chance to get home a shot normal to the belt armor of a passing ship. One such penetration of the vitals by a shell weighing over a ton would do more to wreck the ship than a continued battering by shells of lighter caliber. It is mainly for this last reason that General Flagler, of the United States army, has strongly advocated the building of a certain number of 16-inch guns for coast defense.

The destructive force of a shot may be expended in penetrating the armor or in racking and crushing in the sides of a ship. While it is true that modern 45 or 50-ton guns have a high power of penetration, they fall far below the larger guns in the crushing force of the blow delivered. Thus the 12-inch 45-ton United States gun has a muzzle energy of 26,000 foot-tons, whereas the 16-inch gun will develop over 64,000 foot-tons of energy. The racking effect of such a blow, squarely delivered on the belt armor of a passing ship, would be terribly destructive, even if the shell, as is extremely unlikely, should fail to penetrate.

The recent improvements in the material and manufacture of guns make it possible to turn out weapons of over 100 tons weight that are free from the defects of the early English and Italian guns. The drooping which occurred at the muzzle of these guns after firing a limited number of rounds was due to the short length of the outer hoops, which robbed the gun of its necessary transverse strength. By employing longer hoops and disposing them to better advantage, as is done in our large guns, we have built a 125-ton gun which will prove to be thoroughly reliable.

The accompanying illustration shows the actual penetration of a target by an 1,813-pound Holtzer projectile, fired from one of the 110-ton guns built for the battleship "Sanspareil," of the British navy. The energy of the blow was 54,320 foot-tons, and the shot bored a 16¼-inch hole through 20 inches of compound steel and iron plate, 8 inches of iron, 20 feet of oak, 5 feet of granite, 11 feet of concrete, and finally buried itself in a 6-foot wall of brick masonry.

The new 16-inch gun is a few inches under 50 feet in length. It weighs 280,000 pounds, or 140 tons of 2,000 pounds. The powder chamber is over 1½ feet in diameter and about 9 feet long. The shell weighs 2,370 pounds and the powder charge 1,060 pounds. The shell will leave the muzzle with a velocity of about 2,000 feet per second and an energy of 64,084 foot-tons—equal to the task of lifting sixty-four of the biggest freight locomotives ten feet into the air. At the muzzle, the shell will be capable of penetrating 39 inches of steel, and at a distance of 2 miles it would pass through 27·5 inches of the same material.

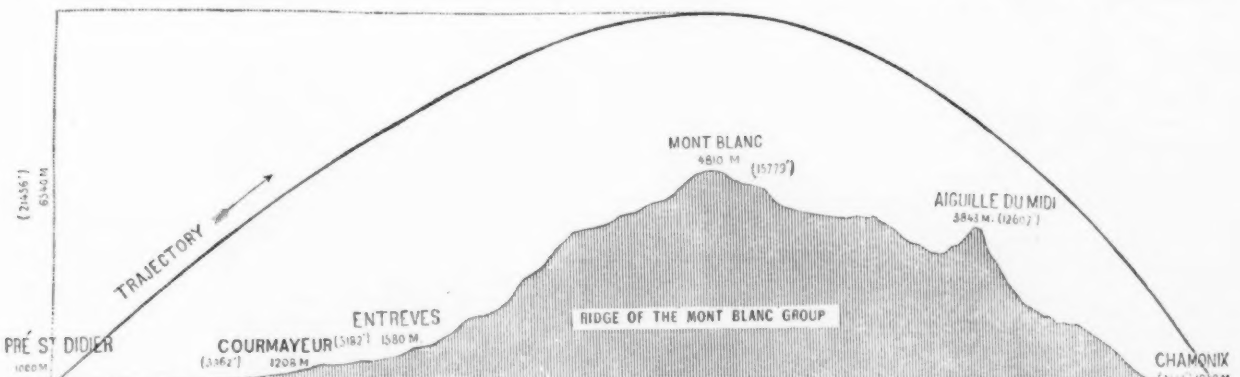
We take the present occasion to correct the popular idea that the biggest guns are intended for fighting at the longest range, the rifles of smaller caliber being reserved for attack when the ship is at close range. As a matter of fact, the 8 and 10-inch guns would open the attack on an approaching fleet at long range, and the 12 and 16-inch guns would reserve their fire for a range at which their projectiles would be sure of penetrating the belt armor and wrecking the vital parts of the vessels.

The Extreme Range of Modern Guns.

Nor is great size necessary to great carrying power. The most remarkable results ever actually attained were secured from a 9·2-inch gun in England and a 9·45-inch hooped gun in Germany. So great is the interest in the question of extreme range, as evidenced by the large number of queries that reach this office from time to time, that we answer the question by the publication of a cut showing the actual course followed by a 9·45-inch shell fired some years ago at Krupp's practice ground at Meppen, Germany. The gun is supposed to be set up at Pré St. Didier and fired with an elevation of 45° in the direction of Chamonix. The shell, weighing nearly one-fourth ton, would rise to an extreme altitude of 4⁶⁄₁₀ miles, or over a mile higher than Mont Blanc, and sweeping across the whole range in a majestic curve, it would fall into Chamonix, 12⁴²⁄₁₀₀ miles from the starting place!

The other famous shot was that known as the "Jubilee Round," which was fired at Shoeburyness, England, in 1888, the year of the Queen's Jubilee. The gun was a 9·2-inch rifle of the wire-wrapped type. A 380-pound shell was fired with a muzzle velocity of 2,360 foot-seconds at 45° elevation. The range was 12·4 miles, or almost exactly that of the Krupp gun, and, as in the latter case, the calculated and actual range were surprisingly close.

The actual range of both naval and army guns is limited by the degree of elevation that can be given to the gun. The extreme range of the seacoast guns, if given an elevation of about 45°, would be for the 16-inch, 13½ miles; 12 inch, 11½ miles; 10-inch, 11 miles; 8-inch, 9 miles; and 6-inch rapid-fire gun, 7½ miles; but it will of course be understood that firing at these ranges would never be desirable, because of the remote possibility of hitting a moving ship at such a great distance.



THE FLIGHT OF A MODERN PROJECTILE. RANGE 12·42 MILES. EXTREME HEIGHT OF TRAJECTORY, 4·6 MILES.

The present scheme of coast defence as drawn up some years ago by the Endicott Board, after an exhaustive examination of the various harbors, roadsteads and cities of the seaboard, recommended that the following guns and mortars should be mounted:

	16-inch.	14-inch.	12-inch.	10-inch.	8 inch.	*12-inch mortars.
New York	18	2	40	20	15	144
San Francisco.......	10	4	20	71	5	128
Boston.............	8	..	10	15	10	132
Lake ports		..	..	..	..	...
Hampton Roads. ..	4	..	10	20	..	16
New Orleans........	..	..	20	..	10	...
Philadelphia...... ..	..	..	10	5	5	16
Washington. ..	..	..	7	6	..	...
Baltimore............	..	..	5	5	5	16
Portland, Me.........	..	..	20	10	10	48

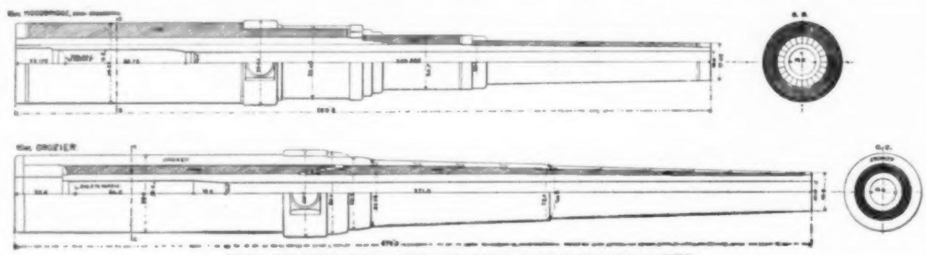
* The question of mortars and high-angle fire is taken up in a later chapter.

Just how far this scheme has been completed it is not expedient for us to say at the present time, but we trust that Congress will make it one of its first duties at the close of the war to issue the oft requested but long delayed appropriations necessary for carrying through to completion this most important work.

WIRE-WOUND GUNS.

THE credit for the invention of the English wire-wound gun is to be given to the late J. A. Longridge, an English civil engineer, who, after nearly forty years of struggle to perfect his device and overcome the prejudice of the British authorities, lived to see the wire-wound gun adopted as the standard weapon of the English navy. His attention was drawn to the subject by observing the frequent failure of mortars during the progress of the siege of Sebastobol in the Crimean war. Speaking of his early work, he says:

"After much consideration, I came to the conclusion that the best method of constructing a cylinder to resist internal pressure was to take a comparatively thin tube and put upon it successive coils of wire, each coil being laid on with a definite tension, varying according to some law, which would be expressed by a function of the radial distances of such coil from the axis of the cylinder. In this way, provided such initial tension of laying on were properly calculated, the completed cylinder would be in a state of varied initial stress, and when such stress was supplemented by the stress arising from the internal pressure due to the explosion of the powder, the stress under fire would be uniform throughout the whole thickness of the cylinder. To determine the proper tension of laying on to fulfill these conditions was a mathematical problem of some complexity, but it was solved and embodied in a formula which is still in use. This invention was the subject of my first patent, dated May 24, 1855."



THE WOODBRIDGE AND CROZIER WIRE-WOUND GUNS.

An experimental gun was built which so completely verified Mr. Longridge's experiments that he offered the device free of cost to the government; but, unfortunately, prejudice and ignorance combined to prevent the adoption of a system which would have advanced the art of gun construction fully a quarter of a century. The matter was finally taken in hand by Mr. Armstrong, who built a weapon which, in its ballistic results, far surpassed anything hitherto accomplished in that country.

This led the government to adopt the wire-wound gun as the service type, and the main armament of the latest battleships of the "Majestic" type consists of 12-inch wire guns in place of the 13·5-inch hooped guns, which were the standard gun in the service. The new weapon is not only more powerful, penetrating 36·8 inches of iron as against 33 inches for the 13·5 inch gun, but it weighs only two-thirds as much, or 46 tons as against 69 tons. Mr. Longridge lived to see this tardy but complete vindication of his principles.

In this country the development of the wire gun is due to Woodbridge, Crozier and Brown, of whose guns we give sectional illustrations. Woodbridge was the pioneer investigator, and as far back as 1850 he presented to the American government an iron gun wound with wire. The gun was a failure, owing to certain mechanical defects in the construction and winding of the wire. Three guns of the Woodbridge type have been tested by the government. The first was a 10-inch wire-wound brazed gun, the test taking place in 1881. This weapon was fractured and parted longitudinally at the ninety-third round. In 1891-92 a Woodbridge 10-inch cast iron wire-wound gun was tested with medium charges of brown prismatic powder, but on account of the inferior power of the gun and the considerable scoring and guttering developed, it was not recommended.

The 10-inch gun shown in our cut may be considered as the prototype of the Brown segmental gun. It consists of an inner tube, an outer segmental core extending from the breech over half the length of the gun, the core being made up of longitudinal bars of steel, and a series of wire wrappings extending the whole length of the gun. This weapon was rendered unserviceable at the twenty-third round by the splitting of the inner tube in five places.

The Crozier 10-inch wire-wound gun is the invention of the army officer of that name, who is better known as the inventor of a most successful disappearing gun-carriage. It consists of a heavy central tube of forged steel overlaid with a practically continuous wrapping of wire from breech to muzzle; a steel jacket, carrying the breech-block and trunnion-hoop, is placed over the wire with a very slight shrinkage and connected at its forward end with the tube. Hoops are shrunk over the chase to protect the wire from being cut by missiles. This gun, unlike its predecessors, has given uniformly good results, and in the words of the testing board "has satisfactorily met all requirements as to rapidity, accuracy, and general efficiency." The gun was designed for a pressure of 42,000 pounds, and 275 rounds were fired, commencing with a pressure of 35,000 pounds (about the service pressure for the hooped guns) and ending with ten rounds in which the pressure exceeded 45,000 pounds. The only defect was that due to the erosive effects of the powder gases, which cut away the commencement of the rifling so badly as to destroy the accuracy of the firing. The Crozier gun is designed for a velocity of 2,100 feet per second with brown powder.

There is now being built and nearing completion for the government a 10-inch wire-wound segmental gun which promises to be the most powerful weapon for its size and weight in the world. It was designed by Mr. J. H. Brown and it is the second of its type to be built, the first, a 5-inch gun, having been built five years ago by the inventor, and tested by the government at the United States proving grounds, Sandy Hook, in December, 1893, and again in May, 1896. The tests consisted of 200 rounds, fired with both brown and smokeless powder. The gun was subjected to excessive powder pressures, the maximum reaching 65,600 pounds to the square inch, and it developed the high muzzle velocity of 3,235 feet per second, without showing any signs of failure.

Theories of the Wire-wound Gun.

Although the principles upon which the wire-wound gun is constructed are thoroughly scientific, they are simple and easily understood. If the modern gun were made in one piece, as were the old cast iron guns, the enormous pressure of the powder gases would stretch the metal lying nearest the bore of the gun beyond its elastic limit before the overlying metal nearer the circumference could come into play and assist in taking the strain.

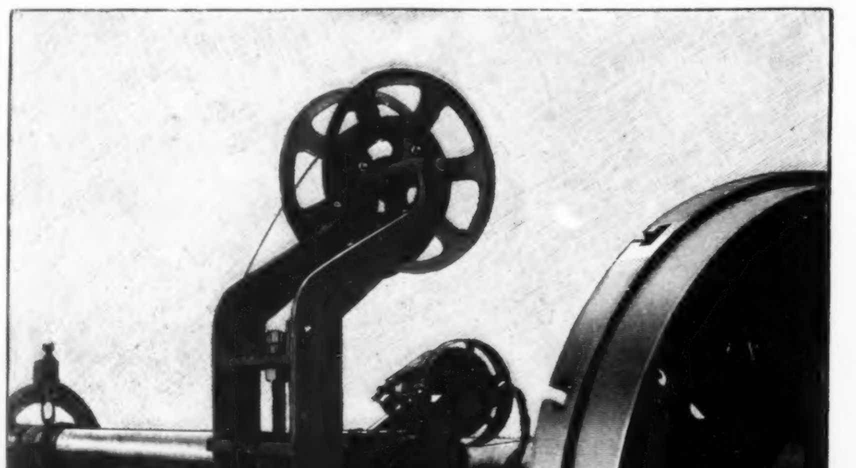
To correct this fault guns are built up, as we have shown in the previous chapter, of a series of overlying cylinders, each series being shrunk on over the others, with the result that the innermost tube is thrown into a state of initial compression. It is evident that upon firing such a gun the shock of discharge will be instantly felt and resisted by every one of the cylinders or "hoops," as they are called, and every particle of metal, from the bore to the circumference of the gun, will be doing useful work. The strength of a built-up gun will depend upon the amount of initial compression and tension which the inner tube and the outer layers can respectively be made to carry, and this in turn depends, of course, on the elastic strength of the metal employed. The efforts of Longridge and Woodbridge were based upon the theory that if, instead of shrinking on hoops, a high grade of steel wire were wound onto the inner core of the gun at a high tension, a much higher compression of the inner tube could be obtained, and greater powder pressures and velocities would be possible. Longridge's experimental gun verified his theories, but failed because sufficient provision had not been made for longitudinal strength. When the system was ultimately taken up by Mr. Armstrong in England, he overcame the difficulties of longitudinal weakness and produced a wire-wound gun which, as we have seen, has been adopted as the standard weapon for the whole British navy.

Now, the limit of strength of the ordinary wire-wound gun will be the elastic strength of the inner core of the gun (for it is evident that the metal must not be compressed beyond its elastic limit), and the elastic limit will be dependent upon the possibilities of manufacture.

Mr. Brown adopts the method of building up the internal compression tube with a number of longitudinal steel bars or staves, and wrapping them together under the tension of the steel wire. By this means he is able to secure a core having a much higher elastic limit than is obtainable in an ordinary tube.

The advantages of this system of making the core are thus stated by Lieut. G. N. Whistler in his admirable theoretical discussion of the Brown segmental system:

1.—In consequence of the small weight of each of the component parts of the gun, crucible steel can be used economically. 2.—The small size of the segments, and the ingot from which they are rolled, admit of their being carefully cast and uniformly forged, so as to insure uniformity of metal, and of their being thoroughly annealed. 3.—As they can be readily rolled into shape, the method of construction is exceedingly economical. 4.—They can be thoroughly and conveniently inspected. 5.—The size and thinness of each segment insures a thorough and uniform tempering and annealing, if temper be considered desirable. 6.—The size of the segments admits of readily setting up conditions of special elasticity by cold work.



WINDING THE THIRTY-SEVEN MILES OF WIRE ON A 5-INCH BROWN SEGMENTAL WIRE GUN.

This last feature is by far the most important one in this system of construction, as it renders it possible to use a character of steel far beyond anything heretofore employed in the core of a gun. The core of such a gun whose bars or shoes have been hardened, annealed and cold drawn could readily be wound so as to produce a compression between the segments of 112,000 pounds to the square inch without exceeding the elastic limits of the material.

Method of Manufacture.

In the manufacture of the 10-inch Brown gun the production of the segmental core is the most novel feature. The segments, which are made from open hearth steel, are cold-drawn and are tapered and beveled in the working. This is done so accurately that no machining is necessary. They are assembled vertically, with the large ends down, in much the same way as a cooper assembles a barrel, and are temporarily held together with three-part clamps placed one foot apart. The core is put in a lathe, the two ends are machined, and the breech and muzzle nuts are shrunk on. The lathe is then set at the taper of the finished gun, and the outside of the core is turned down from nothing at the breech nut to a depth equal to the thickness of the wire, at 12 inches from said nut. Here the operation is again repeated for another 12 inches, and so on until the muzzle nut is reached. The steel wire is $\frac{1}{4}$ of an inch square in section, with a sectional area of $\frac{1}{16}$ of an inch. After the wire has been wound on, the gun is bored out, heated internally by gas, and shrunk onto a thin steel liner. The chase jacket is shrunk on in two-foot sections. The trunnion jacket is interlocked at the breech end by shrinking on, and fits with a slip-joint over the chase. The breech closure is screwed into the projecting end of the jacket, and the trunnion ring is screwed on over the front end of the same jacket, as shown, so that the recoil of the gun is taken up directly by the jacket and transferred by the trunnions to the gun carriage.

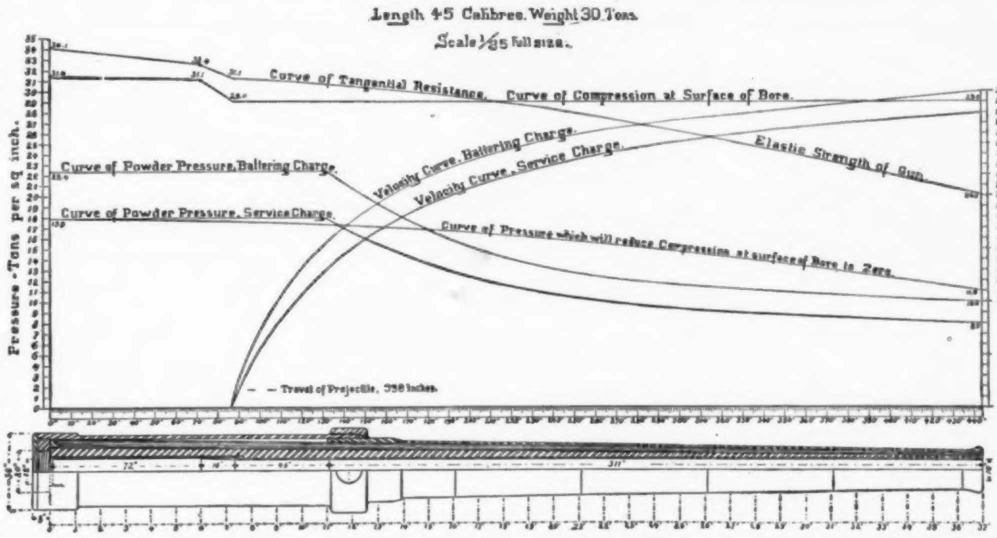
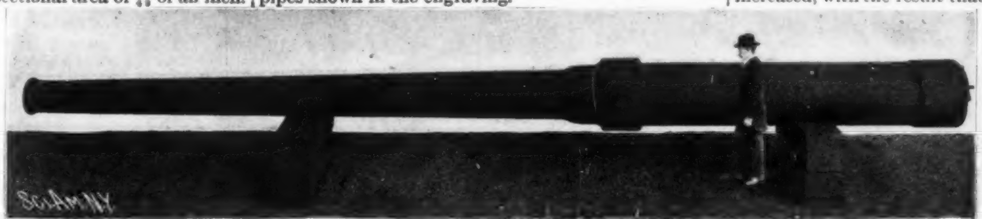


DIAGRAM SHOWING CURVES OF PRESSURE, VELOCITY AND RESISTANCE OF THE 10-INCH BROWN SEGMENTAL WIRE GUN.

The winding of the wire at a constant tension is done by the ingenious machine shown in the engraving. It consists of a stout frame, bolted to the lathe carriage, which is provided with a large overhead spool to carry the wire, and a small car which runs on a track at right angles to the axis of the gun. Upon the car are journaled two sets of adjustable steel rollers, between which the wire passes and by means of which the necessary tension is given to the wire as it passes to the gun. The pressure between the rollers is regulated by means of coil springs, controlled by thumbscrews. The two sets of rollers are geared to two brake wheels, which are seen above and below the car. The upper brake wheel has a fixed brake. The lower brake is automatic in its action and is controlled by the position of the car. From the rear of the car a set of wires passes over the pulley which is seen suspended between the vertical frames, and down to a bracket which carries a certain amount of dead weight. The winding is started with the weight resting on the floor. The handwheel on the brake is then turned until the weight is raised, when the tension in the wire equals the weight. As the car travels toward the gun, the brake wheel is released by an automatic gear, and the car soon finds a position of equilibrium. The brakes are kept cool by the water pipes shown in the engraving.



The wire used in the construction of the 10-inch gun has a total length of 75 miles.

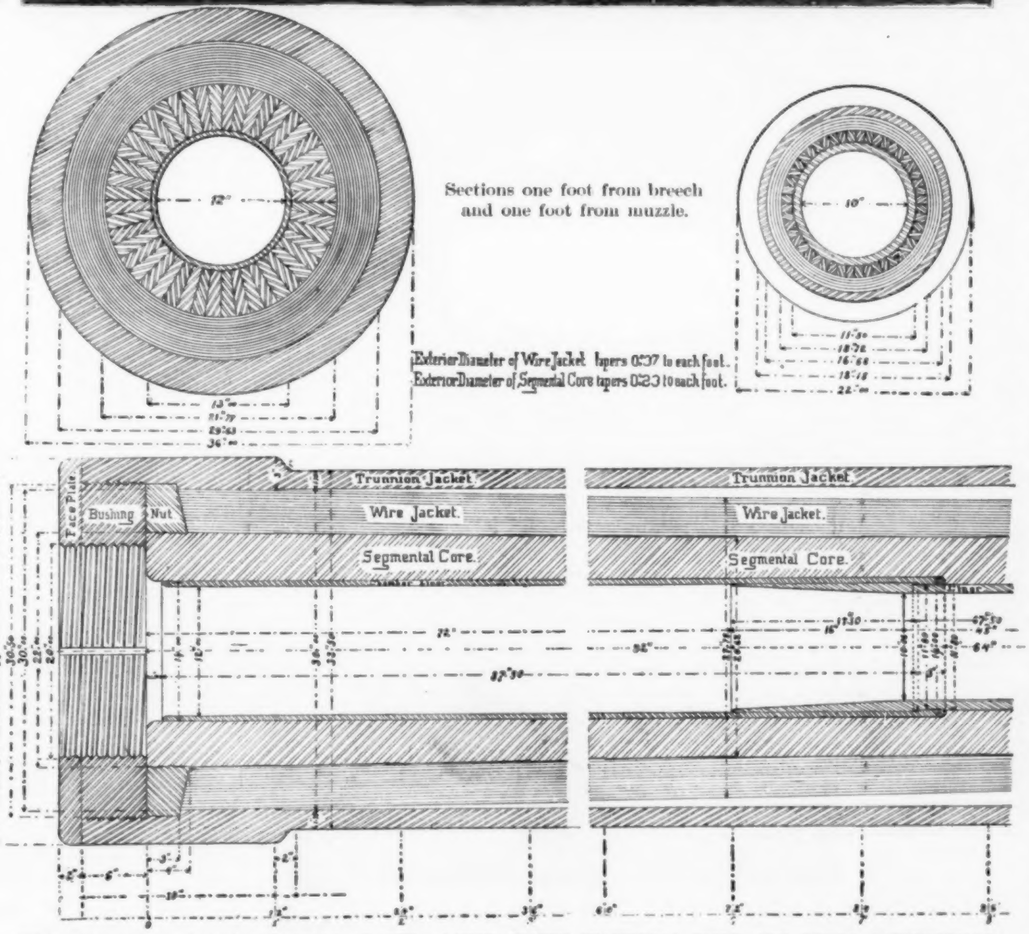
The high quality of steel which it is possible to use in the segmental wire gun is evident from the official tests of the metal put into the 5-inch gun of this type. The segments showed an elastic limit 126,000 pounds per square inch and an ultimate strength of 176,000 pounds per square inch; the wire shows an elastic limit of 230,000 pounds and an ultimate strength of 262,000 pounds per square inch.

Comparison of Wire-wound with Hooped Gun.

We would direct our readers' attention, bearing these figures in mind, to the accompanying diagram showing the curves of velocity, pressure and resistance, from which it will be seen that, when using the battering charge, which gives the enormous velocity of 3,000 feet per second, the curve of powder pressure is never beyond 60 per cent of the elastic strength of the gun. If the segmental wire gun has the necessary endurance—and the army trials at Sandy Hook demonstrate that it has—its superiority over the hooped system of construction is obvious, and explains why the English navy has adopted the Armstrong wire gun as its standard weapon. For with the higher velocities of which the wire-wound gun is capable, the energy of the projectile per ton weight of the gun is enormously increased, with the result that of two ships of equal size, carrying the same total weight of guns, the ship armed with the segmental wire gun will have an enormous superiority of fire. For the same weight it can carry more weapons of equal power, or the same number of weapons of greater power.

This can best be shown by a comparison of the naval 10-inch gun, Mark II, of 28 tons weight, and the Brown 10-inch gun of 30 tons weight which is now being built. The hooped navy gun has a muzzle energy of 15,285 foot-tons, whereas the Brown gun, which is only 2 tons heavier, will have 37,800 foot-tons energy, which, be it said, is over 4,000 foot tons greater than the energy of the 13-inch hooped gun now in service.

Of course there are other questions besides that of power and handiness which will have to be considered, chief among which is that of endurance. The latter can only be determined by a prolonged series of tests such as the Ordnance Board is about to undertake. But if the segmental wire gun should develop no minor defects, it is certain that its enormous power in proportion to its weight will place it far in advance of the pres-



LONGITUDINAL AND CROSS SECTIONS OF THE 10-INCH BROWN SEGMENTAL WIRE GUN UNDER CONSTRUCTION FOR THE GOVERNMENT.

ent style of gun. This is evident from a further comparison of the proposed gun with the standard 13-inch gun of the service.

Style of Gun.	Caliber.	Weight.	Velocity.	Energy.
Hooped	13-inch	60·5 tons	2,100 foot sec.	33,627 foot tons
Segmental wire....	10 "	30 "	3,000 " "	37,800 " "

Such figures as these speak for themselves, and further comment would seem to be superfluous; but we would point out in closing that by adopting the wire gun the "Indiana," without reducing the energy per round of her main battery, would be able to put half of its present weight into larger coal supply, or higher speed, or better accommodation for her crew, and at the same time greatly increase the number of rounds which she could deliver in a given time. If the system were applied to her 8-inch and 6-inch batteries, there would be a proportionate decrease in weight and increase in efficiency.

Limits of space prevent any further discussion of this very live question. Enough has been said to show that the government is fully justified in its determination to build a gun of large caliber and give it a thorough test. It is not enough to say that our hooped guns are the best of their kind; we must have the best of any kind, and if the performance of the segmental wire gun is in every way satisfactory, we cannot too soon adopt it as the service weapon for both army and navy.

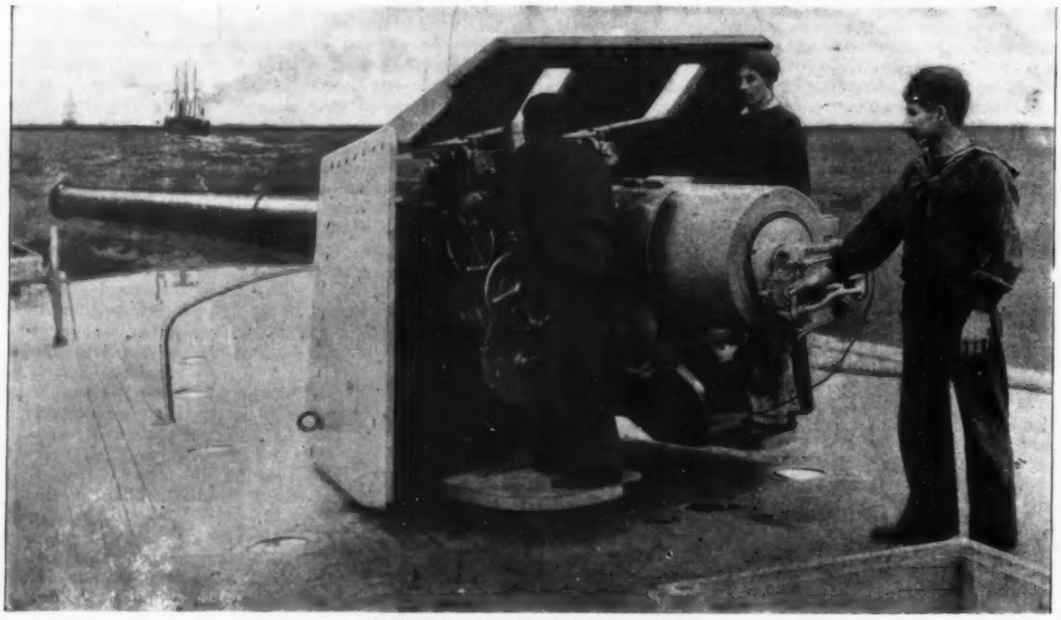
HEAVY RAPID-FIRE GUNS.

OTHER things being equal, the efficiency of a gun is determined by the rapidity with which it can be fired. Given two guns of the same caliber (say 6-inch), whose projectiles have the same penetrating power, and their relative value, whether on shipboard or in the field, will depend upon the number of aimed shells which in a given time they can hurl at the enemy. The most remarkable improvement in ordnance during the past ten or a dozen years is the really astonishing rapidity with which the latest guns of 8 inches caliber and less can be fired as compared with the same calibered weapons of the preceding decade. Proof of this is to be found in the ships of our own navy, where the old slow-firers and the new rapid-fire guns are both to be found installed. The 6-inch slow-firers of the "Baltimore" or the "Oregon" are doing good work if they deliver one aimed shot a minute, whereas the new 6-inch rapid-firers of the "Alabama" will be capable of putting in six aimed shots in the same time, always supposing that the ammunition is supplied from the magazines fast enough to keep the gun going. Now, in the fiercest fifteen or twenty minutes of an engagement, in which the tide of victory will begin to turn to one side or the other, a single rapid-fire 6-inch gun on one side will be equal in its destructive power to any half-dozen 6-inch slow-firers on the other side. However, while this is perfectly true as regards the mere offensive powers of the gun itself, it must be borne in mind that the six separate slow-fire guns would each have its own gun crew, and the chance of disablement through destruction of the crews would be proportionately diminished.

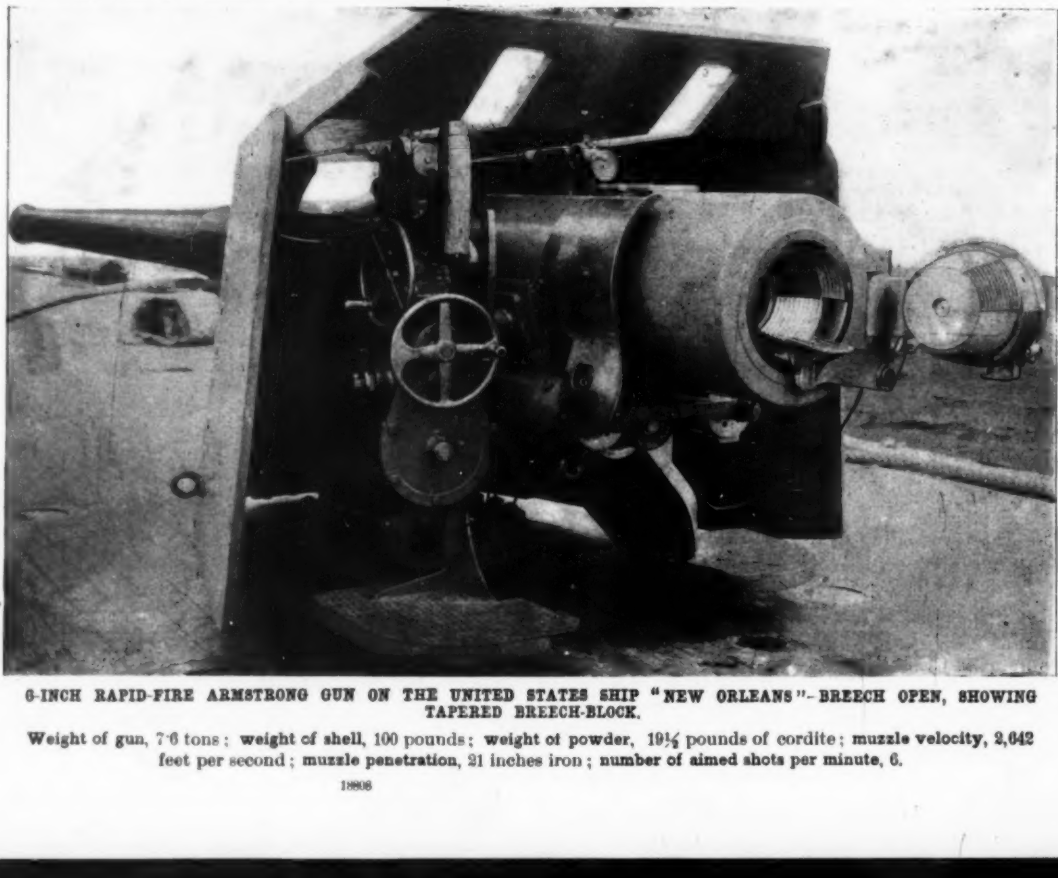
Origin of the Rapid-fire Gun.

We owe the inception of the rapid-fire gun to the torpedo boat. When Thornycroft and Yarrow began to turn out these swift and deadly little craft, a veritable panic fell upon the naval authorities of the world. It was realized that some method of repelling their attack must be found, and found quickly. To test the ability of torpedo boat attack, the British Admiralty at one time organized a raid by nine torpedo boats from the island of Guernsey against a fleet of twenty-four warships, anchored inside the Plymouth breakwater. The distance across the channel to be covered by the torpedo boats was 100 miles, and the attack, which was expected, was made in two divisions, the first at 2 A. M. and the second two hours later. The result was that four of the fleet were torpedoed, and the relative damage to either side, even if it was assumed that every torpedo boat was sunk, was that, for a loss of nine torpedo boats, valued

A 6-INCH RAPID-FIRE ARMSTRONG GUN ON THE "NEW ORLEANS" AT ITS MAXIMUM ELEVATION FOR A RANGE OF SIX MILES.



SIGHTING THE GUN—BREECH CLOSED.



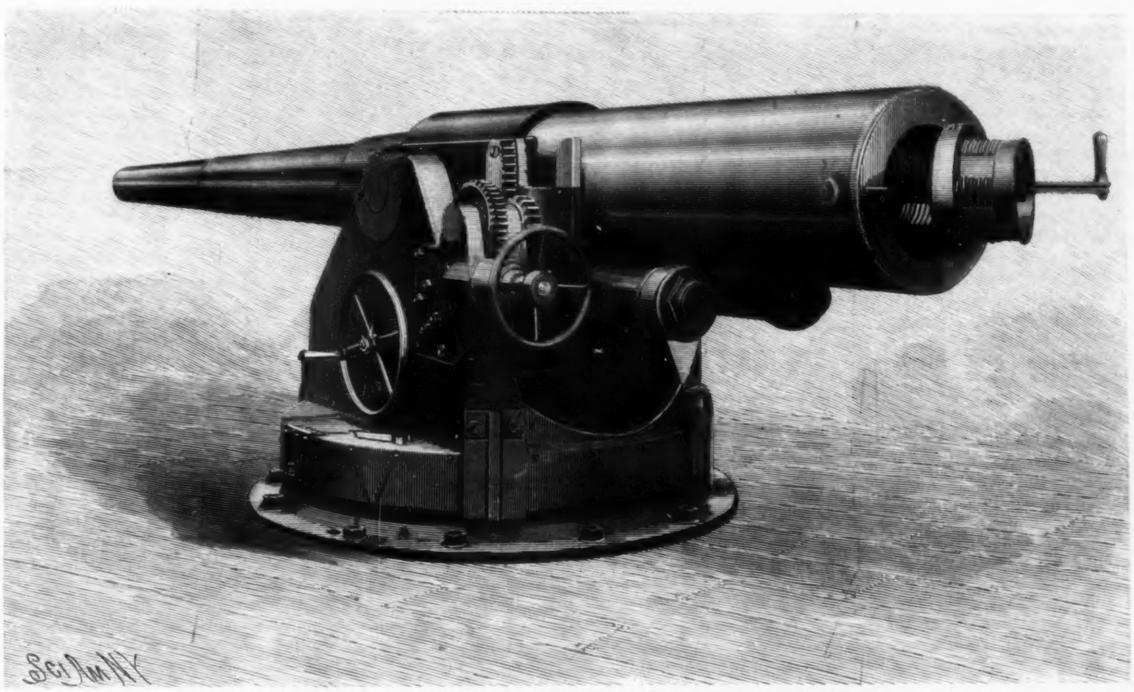
6-INCH RAPID-FIRE ARMSTRONG GUN ON THE UNITED STATES SHIP "NEW ORLEANS"—BREECH OPEN, SHOWING TAPERED BREECH-BLOCK.

Weight of gun, 7·6 tons; weight of shell, 100 pounds; weight of powder, 19½ pounds of cordite; muzzle velocity, 2,642 feet per second; muzzle penetration, 21 inches iron; number of aimed shots per minute, 6.

at $900,000, and 163 men, the attack destroyed three battleships and one cruiser, valued at $12,200,000, and 2,302 men.

At the time when torpedo boats first began to be built, there was no weapon carried on a warship that could make sure of sinking these craft before they could come within torpedo range. As the heavy breech-loading rifles took from three to five minutes to load and fire, the chances of their hitting a small and swiftly moving mark were remote, and although the speed of fire of the Hotchkiss revolving cannon of that day was high, its penetrating power was not sufficient to disable a torpedo poat except at close range. The French government, in 1880, requested Hotchkiss to construct a special gun for stopping torpedo boat attack, and he complied by building a continuous-fire weapon, which discharged a 2½-pound shell. In the following year the English Admiralty invited several firms to submit 6-pounder guns to test. The weapons were to be effective up to 4,000 yards and have a muzzle velocity of 1,800 foot-seconds. The ammunition was to be "fixed," that is to say, charge, shell and primer were to be put up in a metallic cartridge case, as in the small-arms rifle. The recoil was to be automatically controlled and the gun returned to the firing position after recoil: the mount, moreover, was to allow of an all-round fire. A light shield, sufficient to stop rifle bullets at 100 yards, was to be attached to the gun. The French government also invited the construction of a 3-pounder rapid-fire gun, which must penetrate ⅝-inch steel plates 30° to the normal at 2,624 yards range, and be capable of firing 12 aimed and 25 unaimed shots per minute. Hotchkiss entered both competitions and was successful in each. From that time on the name of this famous maker has been closely identified with the development of rapid-fire guns, particularly in the smaller calibers.

We see, then, that the rapid-fire gun was built to meet the demand of the navy for a gun which should have great range and penetration, be capable of quick training on a swiftly moving object, and should be capable of discharging a great number of projectiles in a few moments of critical work. The original rapid-firers were, as we have seen, of small size. The shells weighed 6 pounds or less. These weapons have maintained their position among the multiplied elements of war material as, par excellence, the defence of the warship against the torpedo. We shall treat of these important weapons in the succeeding chapter.



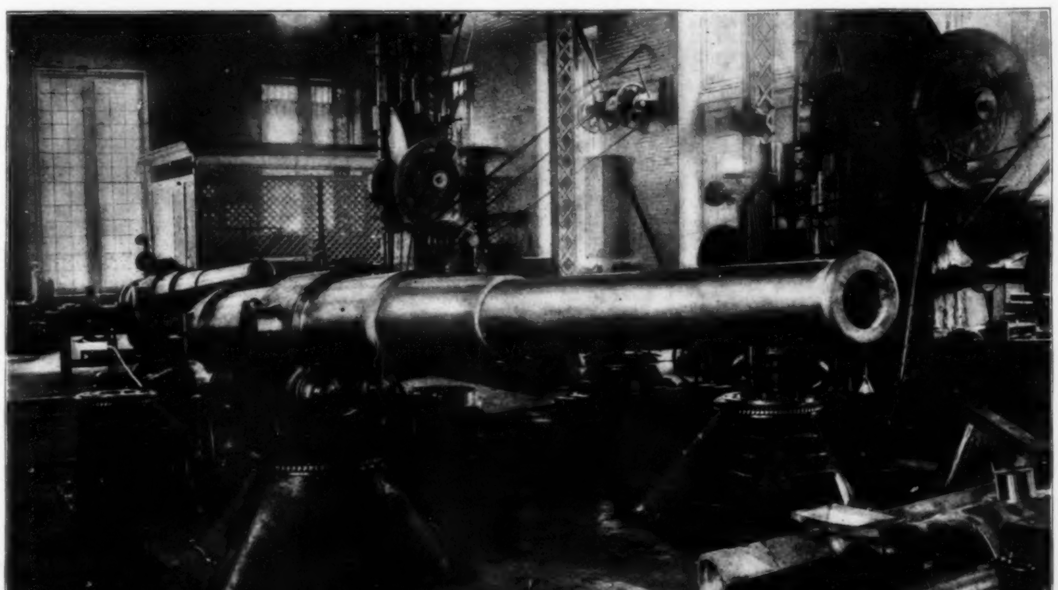
6-INCH NAVAL RAPID-FIRE GUN WITH FLETCHER BREECH MECHANISM.

Weight of gun, 6 tons; **weight of shell**, 100 pounds; **weight of charge**, 47 pounds; **muzzle velocity**, 2,150 feet per second; * **muzzle penetration**, 15·4 inches iron; **number of aimed shots per minute**, 6.

The obvious advantages of rapid-fire in the smaller weapons led the manufacturers of ordnance to attempt its application to the heavier rifles of 4, 5 and 6-inch caliber, and they have met with such success that the secondary 5 and 6-inch batteries in some modern vessels really constitute the most formidable element of the ship's strength.

The speed of the present rapid-fire guns results from the celerity with which the work of loading and sighting can be performed. In one complete round of the obsolete slow-firing type the following separate operations had to be performed: (1) unlock breech; (2) withdraw breech; (3) move it aside; (4) return the gun to battery, i. e., to its position at the forward end of the gun carriage; (5) sponge the gun to remove the unburned residue of the powder; (6) insert the shell; (7) insert the powder charge; (8) swing the breech-block in front of breech; (9) insert it; (10) lock the breech-block; (11) insert primer; (12) remove gun crew out of the way of recoil. Here we have a dozen distinct operations, not to mention the laying of the gun, which was necessary after each recoil—the sights being carried on the gun itself.

Now in the rapid-fire gun these operations are reduced as follows: By an extremely ingenious design of the breech mechanism, operations 1, 2, 3 are carried out by a single sweep of a lever. Operation 4 is carried out automatically by the use of recoil cylinders, in which springs that are compressed by the recoil at once return the gun to battery. Operation 5 is dispensed with and operations 6, 7 and 11 thrown into one by using "fixed ammunition," in which the shell and charge are put up in a metallic cartridge-case with a primer in the base. Operations 8, 9 and 10 are combined by the breech mechanism, the breech-block being swung into line, inserted and locked with one sweep of the lever across the breech, and as the gun alone recoils, the carriage, sights, elevating and traversing gear remaining stationary, operation number 12 is unnecessary and the delay incident to it is avoided. We thus find that the twelve operations involved in the slow-fire gun are reduced to three operations in the rapid-fire. Moreover, in the slow-fire weapon much time was consumed in laying the gun, as the gunner could not get in his work until it had been returned to battery (the firing position), whereas in the rapid-fire type this delay is avoided by placing the sights on the gun carriage (which does not recoil) and placing the gun in a sleeve in which it is free to recoil without disturbing the sights.



5-INCH RAPID-FIRE GUN ON FLETCHER MOUNT.

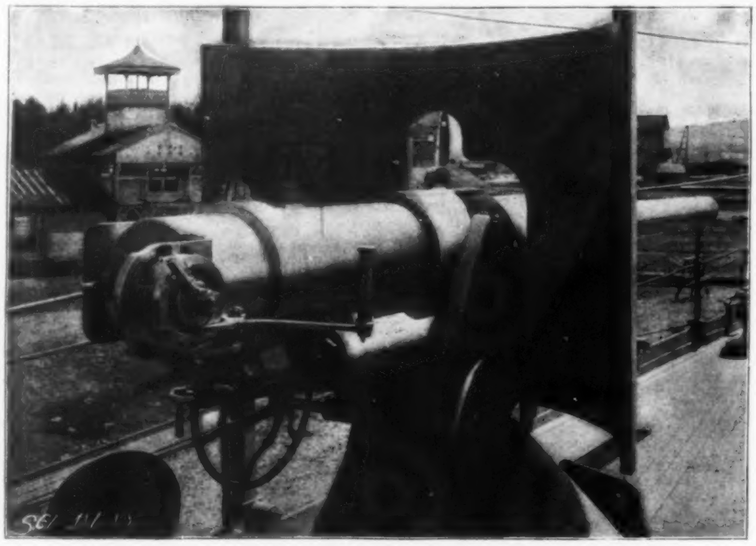
Weight of gun, 3·1 tons; **shell**, 50 pounds; **charge**, 30 pounds; **muzzle velocity**, 2,300 feet; **muzzle penetration**,* 13·2 inches iron; **number of aimed shots per minute**, 10.

Armstrong Rapid-fire Gun.

Of rapid-fire guns, it may be said that their name is legion, and modifications and improvements are following each other so rapidly that it is not easy to keep touch with the advance which is being made. We have

* With smokeless powder, the velocity and penetration could be greatly increased.

chosen for description the three types which, in the larger sizes of rapid-fire guns, are best known in our army and navy—the Armstrong, Dashiell and Fletcher. Although the first-named is one of the pioneer types of heavy rapid-firers and was the first to be extensively employed in the armament of warships (the "Piemonte," built a decade ago for the Italian navy by Armstrong, being the first warship to carry heavy rapid-firers as her secondary armament), we owe our practical acquaintance with this weapon to the exigencies of the present war. Among the war material recently purchased in Europe was a number of 4·7-inch rapid-fire Armstrong guns for coast-defence work (guarding mine fields, etc.) and the two cruisers "New Orleans" and her mate, which were constructed at the Elswick Works and carry the Armstrong weapon. We present three views of the 6-inch rapid-fire guns of the "New Orleans." As this ship is only just out of the builder's hands, her guns represent the very latest improvements in the Armstrong rapid-firer.

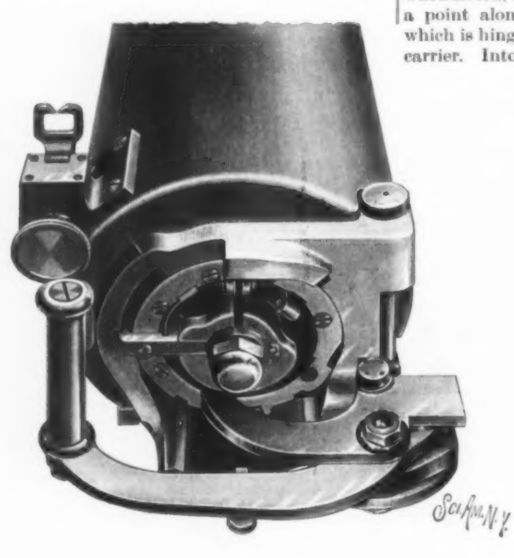


4-INCH RAPID-FIRE GUN WITH DASHIELL BREECH MECHANISM.

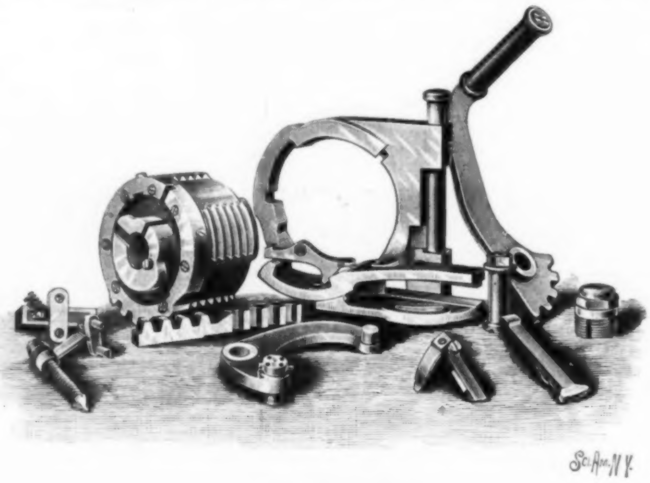
Weight of gun, 1·5 tons; **shell**, 33 pounds; **charge**, 14 pounds; **muzzle velocity**, 2,000 feet; **muzzle penetration**, 9·8 inches iron; **aimed shots per minute**, 15.

The characteristic feature of this gun is the breech mechanism. The breech screw is made on the interrupted screw principle, a part of a turn being sufficient to unlock it. But it differs from the screws of other makers in having its front half steeply tapered, the interruptions on this part coming opposite the full thread on the parallel part; the pressure is thus very much more evenly distributed round the gun than in the case of a parallel screw. Moreover, in opening the breech it is not necessary to withdraw the breech-block before swinging it clear of the breech, the taper on the block allowing it to swing around directly from its seat in the breech-box. The breech-mechanism consists of a strong bronze carrier hinged to the right side of the breech ring. It supports, on a large spigot formed on its face, the breech screw. Rotating round the carrier hinge pin as a fulcrum is a long curved lever, which passes right across the breech of the gun when closed, and terminates in a handle. Attached at a point along this lever is a link, the other end of which is hinged to a block sliding in a guide cut in the carrier. Into this block fits a pin, secured at right angles to the rear face of the breech screw, and at some distance from its center. Suppose now that the breech is closed ready for firing, the long lever and the link lie close against the breech screw, the sliding block being pushed to the limit of its stroke in the guide in the carrier. To open the breech the lever is pulled steadily backward from the gun, just as if the breech were closed by a simple valve or door. This action puts a tension on the link, which in consequence draws the slide block toward the carrier hinge, and this movement must evidently cause the breech-block to receive a partial rotation through the medium of the pin in its face fitting into the block. The continuation of this movement of the hand lever after the unlocking action is complete causes the whole carrier to swing on its hinge, bringing the breech-block out with it. The small tray seen just in front of the open breech is a brass guide piece, which automatically rises to protect the thread from being bruised by the shell when the cartridge is thrust into the breech.

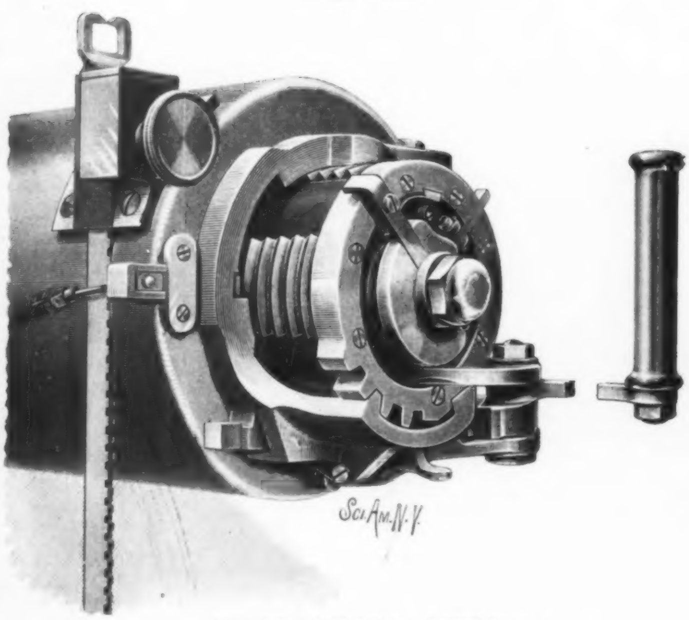
The 6-inch gun of the "New Orleans" is carried in a trunnion sleeve or seating, in which it slides. It is held in the forward or loading position by coil springs, inclosed in two cylinders which form part of the seating. Attached to the gun are two pistons which travel in the cylinders, the latter being filled with glycerine and water. When the gun is fired, it slides back in the sleeve, carrying the pistons with it, and the recoil is checked by the coil springs and by the resistance set up by the liquid in traveling through the pistons, the passage of the fluid being throttled by a gradually closing valve. After the gun has made its full recoil it is returned automatically to the loading



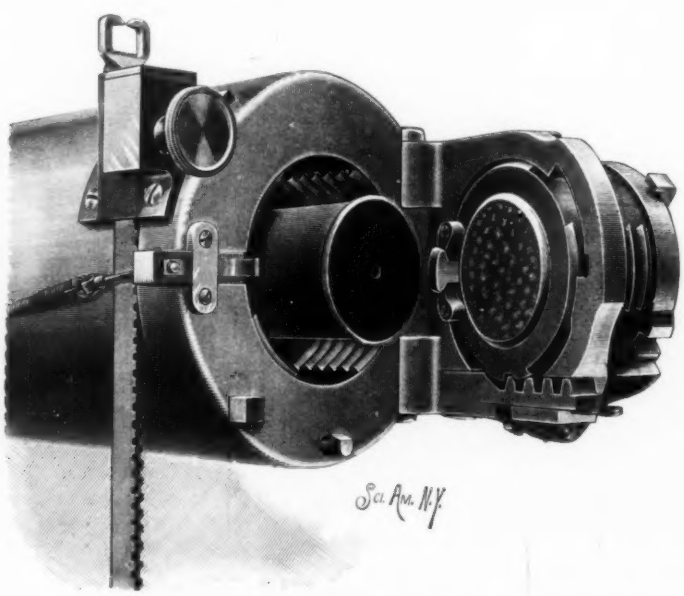
Breech Closed.



Parts Disassembled.



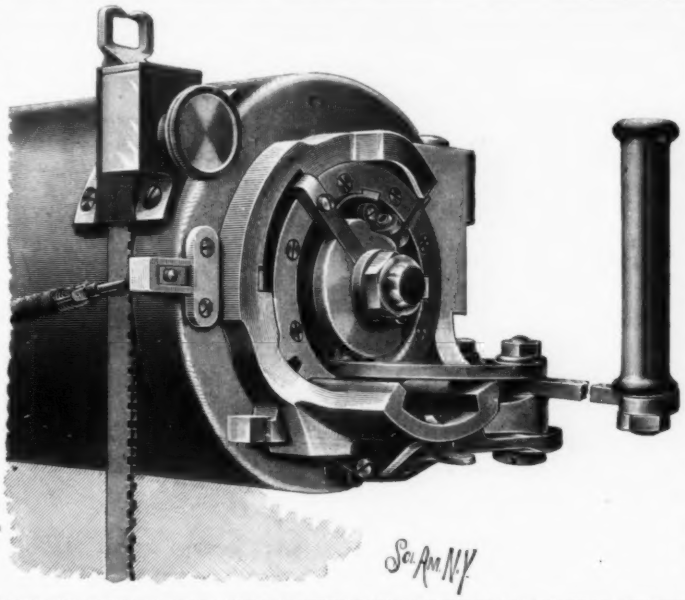
Breech-Block Rotated and Withdrawn



Breech Open and Empty Cartridge Case Started Out by Extractor.

THE DASHIELL BREECH MECHANISM.

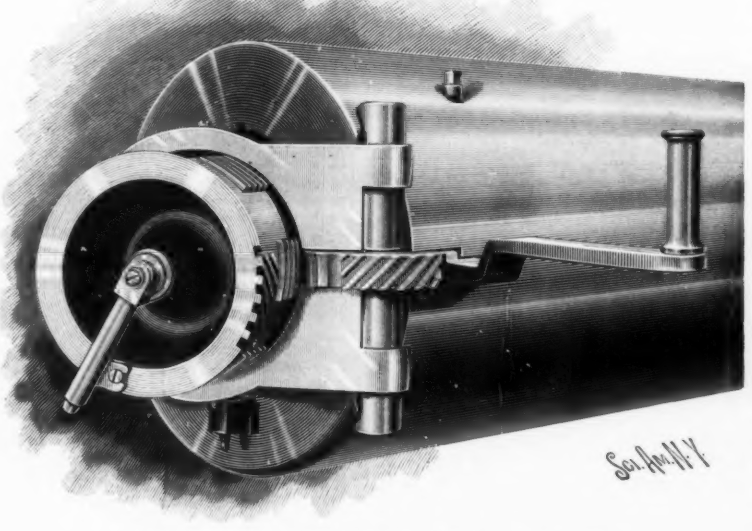
position by the action of the coil springs, which are, of course, compressed during the recoil. The gun and the gun crew are completely protected on the front, sides, and overhead by a Harvey steel shield, which is 4 inches in thickness in front of the gun. The shield comes down close to the deck, and, as it is bolted to the carriage and rotates with it, the crew are safe from machine gun bullets and the lighter rapid-fire shells. The sights, of which there are two separate sets, one on each side of the gun, as shown, are attached to the trunnion sleeve and are not affected by the recoil. The gun is carefully balanced upon a conical mount, which is firmly bolted down to the framing of the deck. It rotates on a race of steel rollers, and the balance, when it is in the loading position, is so perfect that the whole piece, weighing over 7½ tons, can be moved with a very slight pressure. Attached to the left hand side of the carriage and swinging with the gun is a platform, upon which the gunner stands. A similar platform is hung from the right hand side of the carriage and in line with the right hand sights. Just in front of the gunner are two hand wheels, one vertical, one horizontal, for training and elevating the piece. In front of the platform is stowed away a small electric battery from which wires lead to the breech-block for igniting the charge. This is done by the gunner pressing a small rubber air-bulb.



DASHIELL BREECH MECHANISM—BREECH-BLOCK ROTATED BY PARTIAL STROKE OF LEVER.

It is possible that the murderous hail of bullets from an enemy's machine-guns may find its way through the open slots in the shield and carry away the sights. If this should happen, the gun could be given the proper elevation by means of the graduated elevating arc, which can be seen to the right of the gunner. On the inside of the shield to his left is a table giving elevation for various distances, and from this he can read off the number corresponding on the arc to the distance of the enemy's ship.

The reader will see from this description that when it is once laid on the object, the successive firing of the gun will not in the least disturb the elevation or traverse, the gun simply recoiling and returning to battery on its own axial line. The gunner is provided with a shoulder rest, answering to the butt-plate in a rifle. He takes his stand on the platform with his shoulder against the rest, his hands on the elevating and traverse wheels and his eye at the sights, as shown in the center illustration, page 12, and the mechanism is so perfect and the gun so responsive that the big 7½-ton rifle can be swung around, and raised or lowered with something of the speed and ease of a small-arms rifle. The operations of loading do not concern the gunner, who simply has to keep the gun on the object and press the electric firing bulb every eight or ten seconds, or as often as the gun is loaded.



DETAILS OF FLETCHER RAPID-FIRE BREECH MECHANISM.

One of our views shows the gun at its maximum elevation, corresponding to a range of six miles. This is not the maximum range of the gun, for, with 45° elevation, it could throw a shell some nine or ten miles. It is for the reason that guns can only be given a limited elevation on shipboard that the possibility of long range bombardment is very remote in the case of most of our seacoast cities. The 11, 12 and 13½-inch guns of foreign navies are not capable of nearly as great an elevation as the gun herewith illustrated, and their bombarding range would be proportionately limited.

Dashiell Rapid-fire Gun.

The well-known Dashiell breech mechanism, which is in extensive and very successful use on our rapid-fire guns, is called after its designer R. B. Dashiell, of the United States navy. The breech closure is on the slotted or interrupted screw system, but, unlike the Armstrong mechanism, just described, the breech plug and box are cylindrical. The plug is supported when withdrawn on a hinged tray and collar of suitable shape. All operating mechanism is carried on the tray casting, except the trigger, which is on the gun.

A curved translating arm of bell-crank lever form is pivoted on the tray at one end. A vertical toe at the other end engages an undercut score in the breech plug. When this lever swings on its pivot, the plug, if unlocked, will be withdrawn from or entered into the breech.

In the elbow of this arm is pivoted a horizontal cogged segment, formed in one piece, with a long lever ending in a vertical handle or grip. A curved slot in the tray allows its pivot-pin to move with the pivot of the translating arm as a center during longitudinal motion of the plug on the tray. This cogged segment engages a series of horizontal cogs on a rack bar which slides in a groove in front of the tray. The left hand end of this bar is provided with vertical cogs engaging another series on the lower part of the breech plug. A stop-pin on the face of the breech limits the travel of the rack. The length of the rack is such that its extreme right hand cog is immediately below the pivot-pin of the translating arm when the plug is unlocked.

The usual double-acting latch is fitted to the tray.

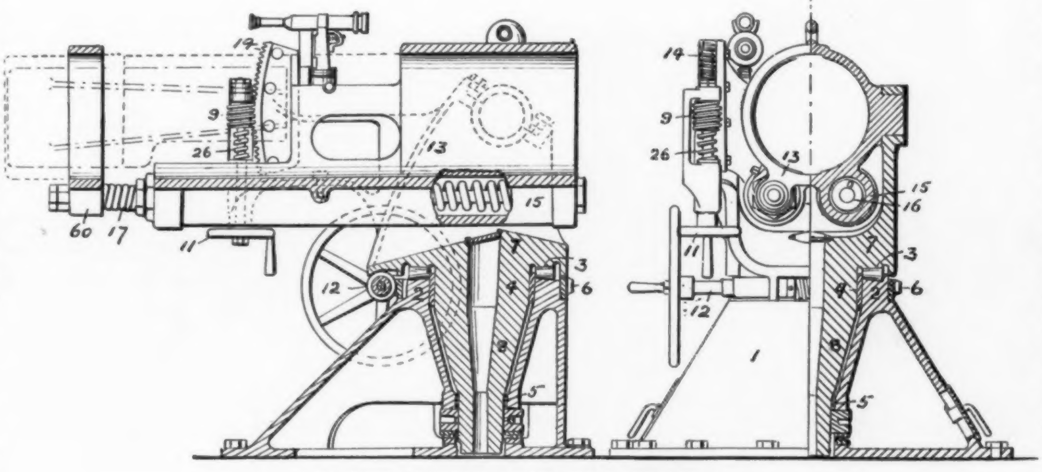
The plug being locked, a pull on the hand lever rotates the cogged segment, thus unlocking the breech plug by means of the rack bar described. As soon as the plug is unlocked the stop pin will have checked the motion of this rack, and the center of motion will be transferred to its right hand cog, which is now immediately below the pivot-pin of the translating arm. The arm and lever consequently swing together, and the plug is withdrawn on the tray and swung to one side clear for loading. As the plug comes out, a groove, cut in its threaded lower segment, passes over the central tooth of the rack.

In returning the plug to the breech two forces will be at work in the mechanism—one to rotate the plug, the other to push it home. The first is checked by the groove in the plug engaging the tooth of the rack mentioned and pulling the plug against the tray rib. Only the motion of translation can thus take place. As soon as it is entirely off the tray ribs the plug can revolve, but, being then home in the breech, its translating motion ceases and revolution locks it in place.

The extractor is a strong bar kept down by a mild spring. It passes through a hole in the plug, so as not to interfere with the threaded parts. By utilizing a certain amount of fore and aft "lost" motion the extractor is kept from slipping off the cartridge head at the same time that the plug, when pulled quickly to the rear through this "lost" distance, acts very powerfully as a hammer to extract the empty case. The extractor is shown in its forward or pulling position. When pushing a cartridge home, the extractor hook cannot rise and catch until it has been pushed back, by the forward motion of the plug, to its rear position. It can then snap over the rim of the case and is ready for the blow from the breech plug in extraction.

The firing mechanism consists of a straight firing pin with cone-shaped shoulder. A spiral spring actuates it, being held to its work by a loose, spool-shaped sleeve. A cocking lever is pivoted to the plug, its upper end running along a cam groove in the tray collar, while its lower end is forked to engage over the spool-shaped sleeve of the firing pin. When unlocking, this lever moves the sleeve to the rear, cocking the pin on the toe of a horizontal sear-bar. When locking, the sleeve is given motion in the opposite direction, which compresses the spring, leaving the firing pin cocked. When fully locked, the outer hook of the sear engages the trigger. A cap over the rear end of firing pin prevents all danger from defective primers.

It will be seen that the gun cannot be



FLETCHER MOUNTING FOR RAPID-FIRE GUNS.

FULLY AUTOMATIC MAXIM NAVAL GUN. FIRES SIXTY 9-POUND SHELLS PER MINUTE.

fired unless the mainspring is compressed and the sear and trigger engaged, neither of which takes place until the last instant of locking.

The lanyard leads forward, around a pulley near the trunnions, if desired, so that the gun captain and lanyard will be out of the way of the gun servants about the breech, and the pull for firing will be independent of the elevation of the piece.

The cut of the 4-inch gun at the top of page 14 shows the electric firing device. The reader will notice a cylindrical tube extending obliquely upward from the center of the breech-plug electric firing device. Within it a bar works back and forth, being forced outward by a stiff spring. As the breech plug is rotated this rotates with it, and in the closing operation it is swung down to a horizontal position, and the projecting end of the small bar, striking an oblique abutment piece on the breech, is driven inward and held so. This closes a gap in the electric circuit. By closing the circuit by hand the primer is caused to operate and the gun is discharged. But if the breech-plug has not been fully rotated, the bar will not be forced in and the electric primer will not operate. This ingenious device entirely prevents the recurrence of those terrible accidents which have at times occurred through the premature firing of rapid-fire guns before the breech was fully closed.

As to the speed of fire and durability of the Dashiell gun, it is sufficient to quote from a report of the chief of the Bureau of Ordnance upon a severe test of a 4-inch gun of the type now doing good service as the main armament of our later gunboats and as the secondary battery of such ships as the "New York" and "Columbia."

"The recently adopted breech mechanisms for rapid-fire guns of 4, 5 and 6-inch calibers have been put to a most thorough test, with both good and defective ammunition. Four-inch gun No. 11 was fired 248 times. The mechanism was worked about 8,000 times with tight-fitting cartridge cases. These cases had to be hammered into the gun, and were selected for the purpose of testing the extractor.

"There has been no failure in the action of any part. A test for rapidity of fire was made before the chief of bureau and bureau officers. Five rounds were fired in seventeen seconds, using experimental cases. Since then, on two occasions, five rounds have been fired in fourteen seconds. On the second trial, the gun was laid at 10° elevation, and all five projectiles were in the air together.

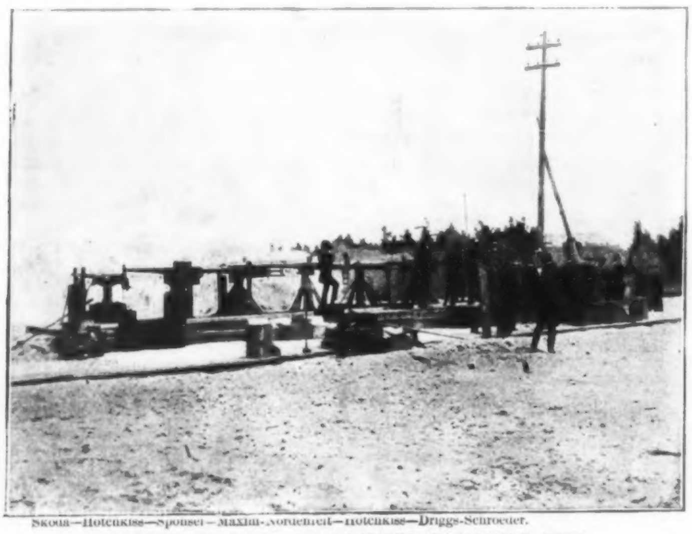
"Similar exhaustive trials have been held with the 5-inch rapid-fire mechanism. Five rounds have been fired, in two instances, in 19 seconds. The charge and projectile made up in one weigh 95 pounds (with brown powder) and can be easily handled by one man."

A further improvement has lately been made in this mechanism in which the blanks are cut out of the breech-box and breech-plug on radial curves struck from the hinge-pin as a center to permit the plug to be directly moved into or out of the breech-box without any withdrawal in the line of the axis of the gun.

The Fletcher Rapid-fire Gun.

In the chapter on the construction of heavy breech-loading guns we have already referred to the Fletcher breech mechanism and mounting as applied to the 13-inch naval gun, and noted the fact that it had reduced the time of opening the breech to 8·72 seconds, and the whole time for a single round of the gun to 1 minute and 47 seconds. In addition to the excellent work which he has done in facilitating the handling of heavy guns, Fletcher has designed some admirable mountings and breech mechanism for the heavier class of rapid-fire rifles, which have taken their place as the standard types for many of the navy weapons. On page 13 we show illustrations of the naval 5 and 6-inch rapid-fire guns with this type of breech and mounting, and detached sectional views will be found on page 15. The same system is shown on page 18 applied to the 3-inch field gun, which is used for such landings as have recently been made by our marines on the coast of Cuba.

The Fletcher breech-mechanism has the distinction of being applied to the first 6-inch rapid-fire guns to be installed on our new battleships. It will be fitted to the 6-inch batteries of the "Alabama," "Wisconsin" and "Illinois," and to those of the three ships recently authorized by Congress. It is also used on the latest patterns of the naval 4 and 5-inch rapid-firers.



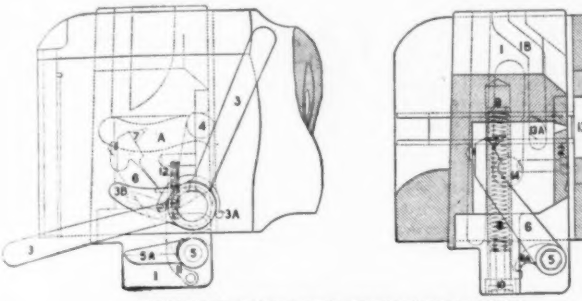
Skoda—Hotchkiss—Sponsel—Maxim-Nordenfelt—Hotchkiss—Driggs-Schroeder.

GOVERNMENT TRIAL OF 6-POUNDER RAPID FIRE GUNS.

DRIGGS-SCHROEDER GUN FIRING 83 SHOTS IN 3 MINUTES.

HOTCHKISS 6-POUNDER. SPEED OF FIRE IN TEST BY GOVERNMENT BOARD, 28 SHOTS PER MINUTE.

In connection with the following description the reader is referred to the engraving on page 15. The breech-mechanism is of the interrupted-screw type, with four threaded portions and four blanks. A rack with teeth at 45° to the axis of the plug is cut partially around its circumference in rear of the threaded portion. A carrier-ring, hinged upon the same pin on which the operating lever turns, is cut on its inner circumference with blanks and raised portions to allow



HOTCHKISS RAPID-FIRE BREECH-MECHANISM.

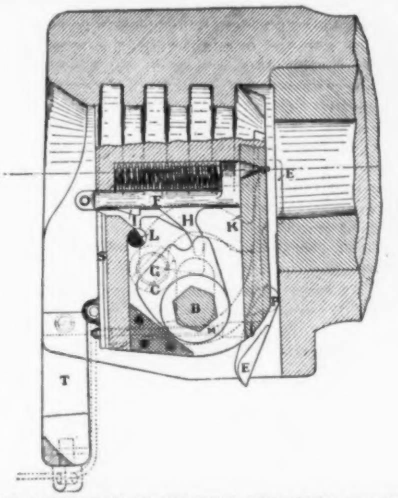
the plug to move forward and back in it. The carrier-ring is slotted through radially in the upper left quadrant to receive a locking device, which locks the carrier-ring to the gun when it is swung to, and locks the plug in the carrier-ring when the former is withdrawn. The operating lever has a vertical grasp at its end and pivots on the hinge-pin on the right side of the breech. The rear surface of the lever at the hinge-pin is shaped to act as a cam on one end of a small extracting lever, the other end of which catches the ring of the empty cartridge case and starts it from its seat in the gun. The front right-hand surface of the lever is shaped into a segment of a circle and cut with five teeth to fit the circumferential rack-teeth on the plug, and four teeth of the same section as the threads on the plug.

The action of the mechanism is as follows: The breech-block being closed and locked, the rear tooth on the lever is engaged with the lower tooth of the circumferential rack on the breech-block, and the extraction claw is under the rim of the cartridge-case. The lever is swung to the right through an angle of about 60°, thereby successively engaging its teeth with those of the rack on the breech-block and causing the latter to rotate 45° to the left, disengaging its teeth from those in the breech-box and leaving it free to be withdrawn. At this moment a locking-bolt prevents any further rotation. At the same instant the withdrawing-teeth on the lever begin to successively engage the threads of the breech-block and cause the latter to move to the rear through the carrier-ring. The further movement of the lever through 44° completes the withdrawal of the breech-block, locks it to the carrier-ring, and swings them both clear of the breech. During the last part of their motion, the cam-shaped rear face of the lever causes the extractor to start the empty cartridge case, slowly at first and then with great force, loosening it so that it can be easily withdrawn by hand. The electric firing device is similar in its operation to that described on the Dashiell mechanism, and full protection is assured against the premature discharge of the gun before the breech is closed.

Pedestal Mounts for Heavy Rapid-fire Guns.

It is a curious fact that in the endeavor to produce a perfect rapid-fire gun of the larger type which we are now considering, more attention has been paid by inventors to the breech-mechanism than to any other feature of the gun, although, as a matter of fact, the improved mounting, sights, elevating and traversing mechanism have contributed as much, if not more, to speed of fire than the breech gear. The following is a description of the standard mounts used for the larger rapid-fire guns in our service: The foundation of the mount (see diagrams on page 15) is a hollow steel pivot-stand (1) which is securely bolted to the platform or deck. The top is machined to form a path for a number of conical steel rollers (3). Just below the rollers is a circular training arc (6). The pivot socket is fitted at top and bottom with bronze bushings, 4 and 5. The top carriage is a steel casting in the form of a yoke, provided with trunnion seats in the brackets and terminating in a stout vertical coned pivot (8). The carriage rotates on, and is carried by, the steel rollers (3), and the vertical cone rotates freely in the bushings, 4 and 5. At the bottom of the coned pivot a large nut serves to keep the carriage down in place and take up any slack in the adjustment. The gun is carried in a slide (13). On each side of the slide are formed the trunnions, and below it are two recoil cylinders (15), the slide, trunnions and cylinders being cast in one piece. The left side of the slide is prolonged to the rear to carry an elevating arc, 14, and an arm on the left side of the top carriage carries an elevating shaft and a worm (9). The training-arc (6) is engaged by a worm which is held on a horizontal training-shaft (12). The training-shaft works in bearings on the lower edge of the top carriage, and has a large hand training-wheel on each end. The mount permits of an all-round train of the gun. The piston rods of the recoil cylinders extend through special stuffing-boxes at the rear ends, and pass through a heavy steel yoke (60) which is shrunk on the breech of the gun. At the rear of the pistons in each cylinder are three coil springs, which act with the glycerine and water to resist the recoil. The springs return the gun to the loading position after firing. Buffer springs (17) are interposed between the yoke and the rear ends of the recoil cylinders.

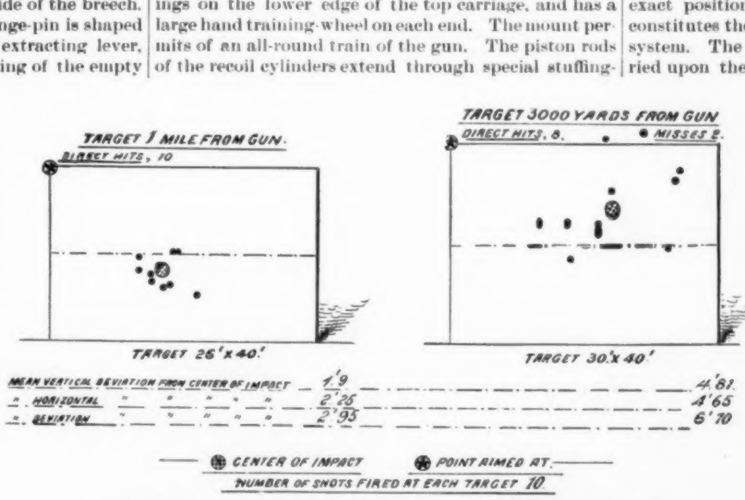
To provide for the downward shock of the gun at the instant of firing, the elevating worm (9) is keyed to the shaft by feathers, which permit the worm to move vertically, but prevent any rotation. Beneath the worm is a coiled spring (26). The worm is depressed when the gun is fired, but is returned by the spring to the



DRIGGS-SCHROEDER RAPID-FIRE BREECH-MECHANISM.

previous elevation as the gun returns to the loading position. It is this return of the rapid-fire gun to the exact position in which it was laid before firing that constitutes the most valuable feature of the rapid-fire system. The old slow-fire weapon, with its sights carried upon the gun itself, required resighting carefully after each discharge; whereas in the new type, the gunner can hold the gun permanently upon the mark, his eye never leaving the sights.

As an evidence of the immense gain in rapidity by the use of this system of mounts and breech-mechanism, it may be mentioned that in an official test to determine the utmost speed of firing, five rounds were fired from a 4-inch gun in 15 seconds, from a 5-inch gun in 20 seconds and from a 6-inch gun in 50 seconds. The actual speed of fire, taking careful aim, would be somewhat less in the 4 and 5-inch guns, but the figures given under our accompanying illustrations are quite within the powers of a first-class gun detachment.



TARGET RESULTS IN OFFICIAL TEST OF HOTCHKISS 6 POUNDER.

Application of Rapid-fire Mechanism to the Heavy Breech-loading Rifles.

At present rapid-fire mechanism is only applied in the United States to guns of 6-inch caliber and under. The question of using it on guns of 8 to 12-inch caliber is suggested by the fact that very successful 8-inch rapid-firers have been constructed by some foreign builders. On account of the increase in size and weight of the ammunition, it is, of course, impossible to secure the extreme rapidity of fire obtained in the smaller guns; but the increase in speed is, pro rata, equally remarkable.

Armstrong is mounting as the main armament of the fast cruisers, such as the "Esmeralda" and the "O'Higgins," which he is constantly building for South American republics, an 8-inch rapid-fire gun which has shown remarkable results as to power and speed. The general features of the mounting and breech mechanism of this gun are the same as those of the 6-inch guns, already described, of the "New Orleans." The ammunition, however, on account of its weight, is not put up in a single cartridge case, the shell and the powder being placed in the gun separately for convenience. Nevertheless, in the official test of the "Blanco Encalada," built for the Chilean government, four rounds were fired from an 8-inch gun in 62 seconds, *the ammunition being supplied from the magazines.*

It is best to look facts squarely in the face, and there is little comfort in the

DRIGGS-SCHROEDER 6-POUNDER WITH BREECH OPEN.

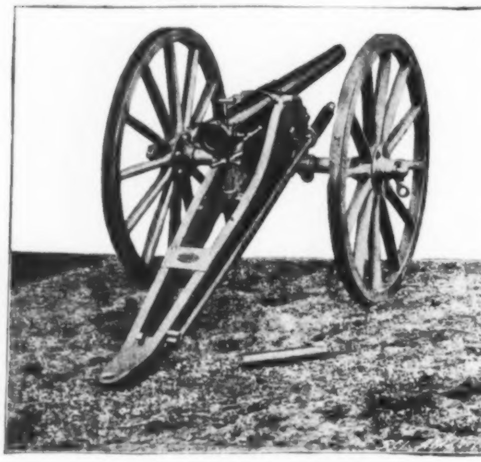
10018

thought that, should the "Brooklyn" and the Chilean "Blanco Encalada" ever meet in battle, the latter could deliver as many shells from her two 8-inch quick-firers as the "Brooklyn" could from her eight 8-inch slow-firing rifles in the first few minutes of the fight. Of course, some of this celerity is due to the advantages of using smokeless powder; but smokeless powder and the rapid-fire gun are, or ought to be, the necessary counterparts of each other, and when smokeless powder is made the exclusive service powder of the army and navy, we hope that the guns that use it, whether they be of the medium or the largest calibers, will be furnished with every possible equipment of the rapid-fire kind.

There are other European manufacturers, such as Krupp and Canet, whose tables of rapid-fire guns contain weapons of as large as 9·45-inch caliber, and the records of recent firings with the 12-inch wire-wound guns of the "Majestic" type of battleship almost entitle these weapons to be ranked in the class of semi-rapid-firers. In recent trials two guns were fired three times each in 107 seconds, the time being taken from the first discharge to the last. The time between the second and third rounds was only 49 seconds. This rate of fire maintained from both turrets would mean the delivery of 5 tons of metal, capable of penetrating 36 inches of iron and having a combined energy of nearly 400,000 foot-tons, in less than two minutes time.

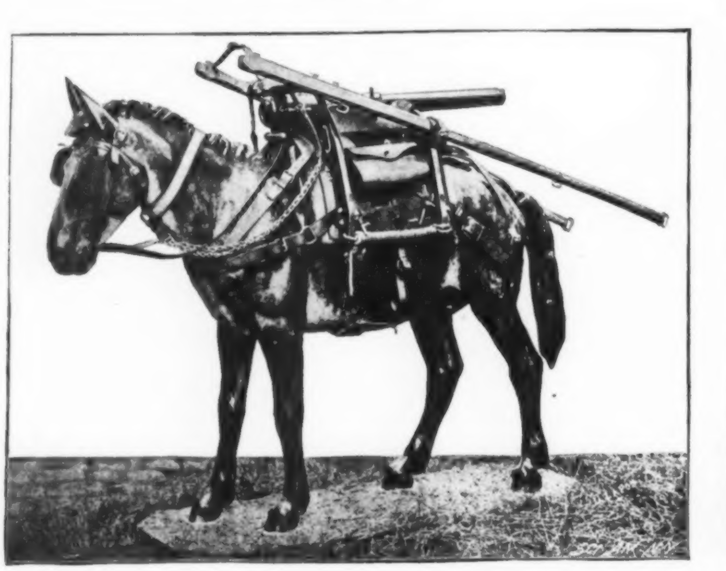
We refer to this subject at considerable length because we feel that it is imperative, especially in view of the larger international field upon which we, as a nation, are entering, that we should keep fully abreast of the march of improvement in war material. In respect of powder and rapid-fire guns, we have fallen somewhat behind in the race. The urgent representations of ex-Assistant Secretary of the Navy Theodore Roosevelt regarding the necessity of replacing the slow-fire guns on our cruisers and battleships with more modern weapons are fresh in our ears. The change is being made, we are happy to say, as fast as circumstances will permit, and before long we hope to see the older weapons entirely replaced by the excellent Dashiell and Fletcher guns which we have just described.

The speed of fire of our heavy rifles of 10 inches caliber and over is, as we have already noted, greater in the navy than in the army. It might be increased in the navy by a further application of mechanical power in such operations as are yet performed by hand, and in the seacoast guns by the installment of mechanical power in those batteries, or at least in the more important of them, the effectiveness of which is, at present, somewhat crippled by the hand-power methods of manipulation in use.

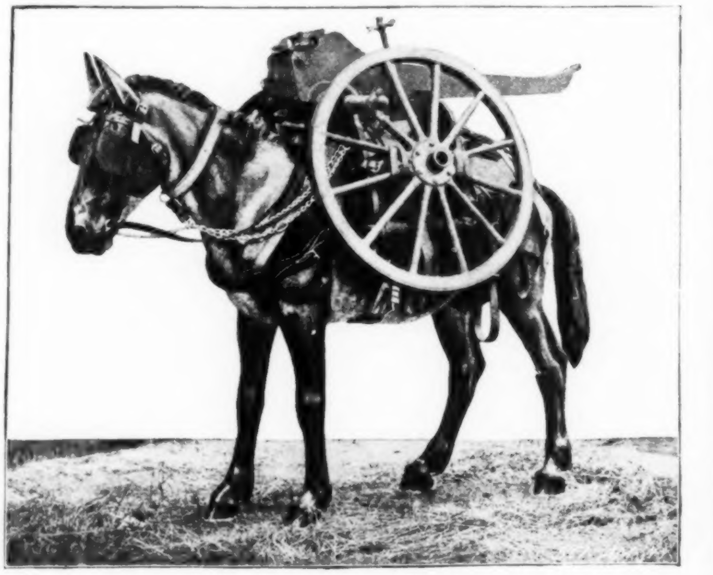


Hotchkiss 2-pounder Mountain Gun.

Ammunition Mule.



Gun Mule.



Gun-Carriage Mule.

HOTCHKISS 2-POUNDER MOUNTAIN GUN IN BATTERY AND IN TRANSIT.

LIGHT RAPID-FIRE GUNS.

IN the previous chapter it was shown that the introduction of the rapid-fire gun was due to the demand for a weapon capable of stopping the attack of torpedo boats. Of the three manufacturers who in 1880 and 1881 offered a suitable weapon, in response to the request of the French and English governments, Hotchkiss was the successful bidder, and the pre-eminence which he then achieved has been retained ever since. To-day, in spite of the fact that there are about a score of firms who make a specialty of rapid-fire guns of the smaller sizes, the Hotchkiss, or the guns that are built on the Hotchkiss general lines are, par excellence, the weapons for stopping torpedo boat attack, and indeed for all classes of work, whether on fortifications or afloat, which it is the duty of the "pounders" (guns whose size is designated by the pound weight of the projectiles) to perform.

The Hotchkiss 6-pounder.

The construction of the Hotchkiss guns, and indeed of all the lighter rapid-firers, is much simpler than that of the heavier weapons. They usually consist of two main parts, an inner tube and an outer jacket, though some makers are building very successful guns of a single tube. The Hotchkiss gun consists of an inner tube over which is shrunk a jacket, the latter being extended at the breech of the gun and enlarged to carry the breech mechanism. This is of the "wedge" system, as distinguished from the "interrupted screw" system already described. The breech-block, which is rectangular in its horizontal section, moves vertically in a slot which is cut through the extension of the jacket immediately in rear of the bore of the gun. The front face of the block is exactly normal to the axis of the gun, while the rear face is slightly inclined or wedge shaped. The firing mechanism is carried within the breech block.

As the block moves vertically and falls of its own weight, the function of the mechanism for opening and closing is to lift the block up in closing and to keep it from falling open when closed or from falling completely out when the breech is opened.

The block is opened (i. e., let fall) by means of a crank (4), having a stud on the end which fits in a slotway, A, in the right side of the block, and the block rests entirely on it. When the crank is turned, the stud sweeps down or up through its arc, and the block is carried down or up with it. When the breech is closed, the block is kept from falling by the crank being slightly past the vertical to the front, and also by a light automatic spring-catch on the handle.

The rocking-shaft (5) carries the hammer (6) and has a toe, 5A, which, when struck by the cocking cam, 3B, on the crank, turns the rocking-shaft and retracts the hammer (6). When at full cock, the firing system is caught by the gear (11), which is actuated by the sear spring (12). During this portion of the movement of the crank (4), owing to the curve of the slotway, A, the breech-block does not move; but as soon as the hammer is cocked, the block commences to descend, and as it moves down, the cartridge-case extractor (13) is moved directly to the rear, slowly at first, and with a powerful leverage, to start the cartridge-case from its seat, and then quickly, as the bore is unmasked, throwing the cartridge-case out of the gun. When it is completely down, the breech-block is caught and held by the stop bolt (14).

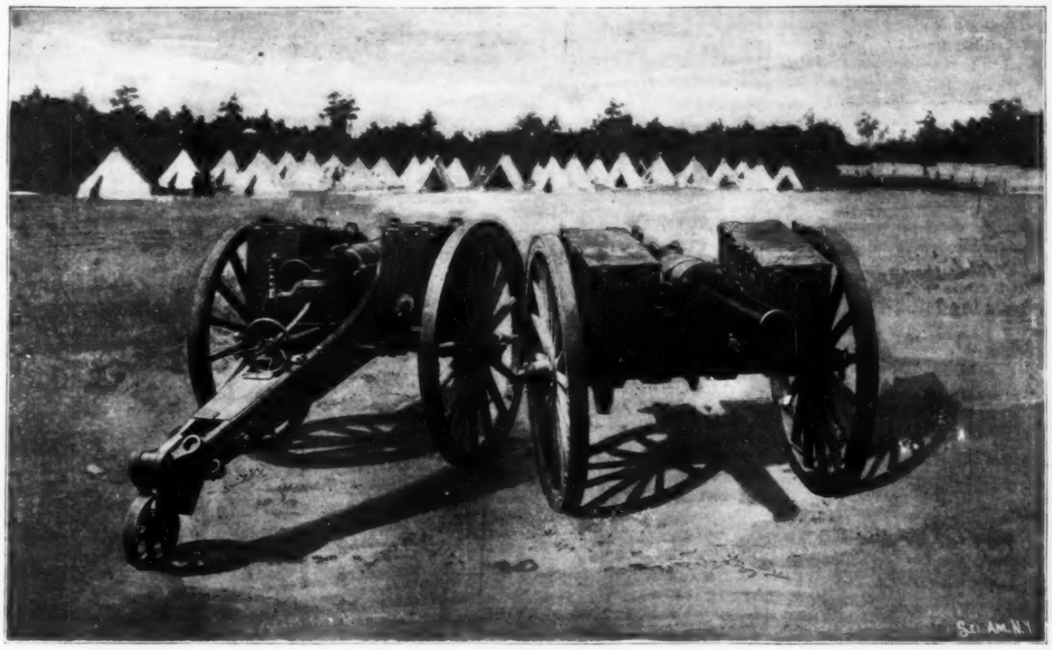
In loading the gun, the charge is entered in the chamber and pushed home until the head of the case fetches up against the hook of the extractor. The block is then closed by a reverse motion of the crank handle. As the block rises, its inclined, forward, upper edge pushes the cartridge and extractor close home. When the breech is closed the cocking-toe is in position to allow the cocking-arm, and with it the hammer, to act in firing. Pulling the trigger now fires the charge.

For aiming, a stock (see illustration, page 16) is bolted to the left side of the piece if the gun is mounted on a rigid carriage, or to the left side of the carriage if the gun recoils. The stock carries a shoulder-rest consisting of a short length of rubber tube. The recoil is taken up by a coiled spring carried in a small cylinder below the gun, its action and advantages being similar to those already described in connection with the heavier guns. The naval gun is mounted with its trunnions resting in a pivoted yoke which turns in a stout pivot stand. This motion, combined with the vertical motion of the gun on its trunnions, enables the piece to be given a motion in any desired direction.

The Driggs-Schroeder 6-pounder.

Another excellent make of gun in our service is the Driggs-Schroeder, an American invention. Its most interesting feature is the breech-mechanism, shown in the two cuts, page 17, which has a combined falling and turning movement in opening. The breech-block is provided with grooves and projections cut upon its top and sides which fit into corresponding recesses in the top and sides of the breech recess. The main bolt, B, actuated by the opening lever, carries a cam, C, rigidly attached to it. As the bolt is turned, the cam turns in its seat in the block and the latter is forced down until the pin, L, in the block, drops into the seat on the upper part of the cam. The block ribs are now clear of the grooves and the block turns back in com-

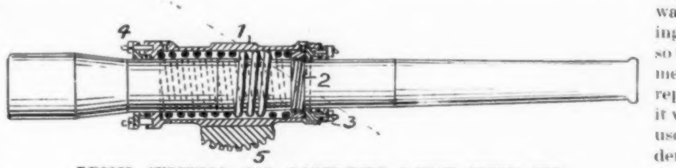
mon with the cam until it rests on the tray T. A lug, H, projects from the lower part of the firing-pin, F, into a groove in the upper part of the cam, C. When the cam is revolved, the firing-pin is retracted against the main-spring until the cock notch, L, catches over the sear, S, which is held in position by a sear-spring. There are two extractors, EE, which revolve on pivots, P. The tails of these extractors are cammed by the bottom surface of the breech-block. The block having a certain amount of vertical motion with regard to the main bolt, it must be kept in the lower position relative to it during rotation. To this end a guide-bolt, G, is screwed through each side of the housing, projecting into a guide-groove cut in each side of the block; this groove is so shaped that the bolt permits only the vertical and rotary motions in proper order.



3 INCH RAPID FIRE FLETCHER FIELD GUN.

Rapidity and Accuracy of the Light Rapid-fire Gun.

With his shoulder at the shoulder-rest, his hand on the trigger, and his eye on the sights, the gunner is able to keep his weapon constantly trained on the approaching torpedo boat, and he pulls the trigger just as fast as the gun crew can load the weapon. Given an expert gunner, and the chances of a torpedo boat getting within range will depend upon the speed and accuracy of the gun. Just what this is, the reader can judge from the diagram on page 17, showing the actual target results obtained in a government test of a Hotchkiss 6-pounder, made in the summer of 1894.



RECOIL CYLINDER FOR RAPID FIRE 3-INCH FIELD GUN.

In the first trial, against a target measuring 26 feet high by 40 feet wide and one mile distant from the gun, of ten shots fired, all struck the target, and the mean deviation from the center of impact was less than 2 feet. In the second trial the target measured 30 by 40 feet and was placed at 3,000 yards from the gun. There were eight hits and two misses, and the mean deviation was only 4·8 feet.

So much for the accuracy of these deadly little weapons.

As regards the rapidity of fire, we cannot do better than give further details of the government tests above mentioned, which were carried out at Sandy Hook for the purpose of testing the relative efficiency of four 6-pounders of the following types: Hotchkiss, Sponsel, Maxim-Nordenfelt, and Driggs-Schroeder. There was also tested, but not in competition proper, a 3-pounder Skoda gun. The tests were conducted under the supervision of Captains Heath and Crozier. The guns were fired directly out to sea, the whole object of this test being the determination of the rapidity of firing and the time required for replacement of parts, the questions of accuracy of firing or penetration not being considered on this occasion.

The firing tests were conducted on the following basis: The first test was to determine how many shots could be fired in one minute. The next test was to determine how many shots could be fired in three minutes. Then came the taking apart trial. This consisted in firing one shot, taking out some of the breech parts and replacing them by others, and firing a second shot. The time was taken between the first and last shots. Finally came a speed trial of three successive intervals of five seconds for each gun.

In conducting the tests a crew of four men was assigned to do the actual work of firing. This crew moved from piece to piece, so that each rifle was fired by the same set of men. Besides these each gun had its own representative, and in the taking apart trial it was he who did the work. The cartridges used were charged with ordinary black powder, except in the case of the Skoda gun, an Austrian piece, which used a smokeless powder. The only smoke visible when this piece was discharged was a slight haze. Although not regularly in the competition, a record was taken for it. The following are the records obtained in the three principal trials:

Driggs-Schroeder—Number of rounds fired in one

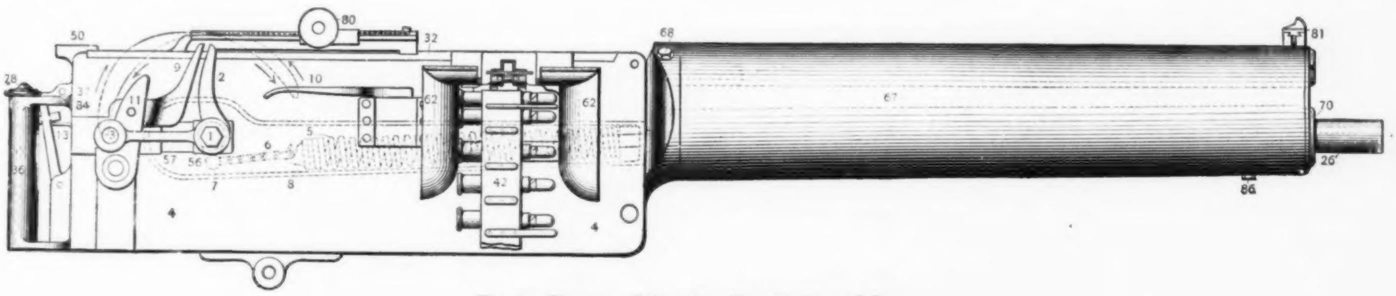


Fig. 1.—Diagram of Non-Recoiling Portion of Gun.

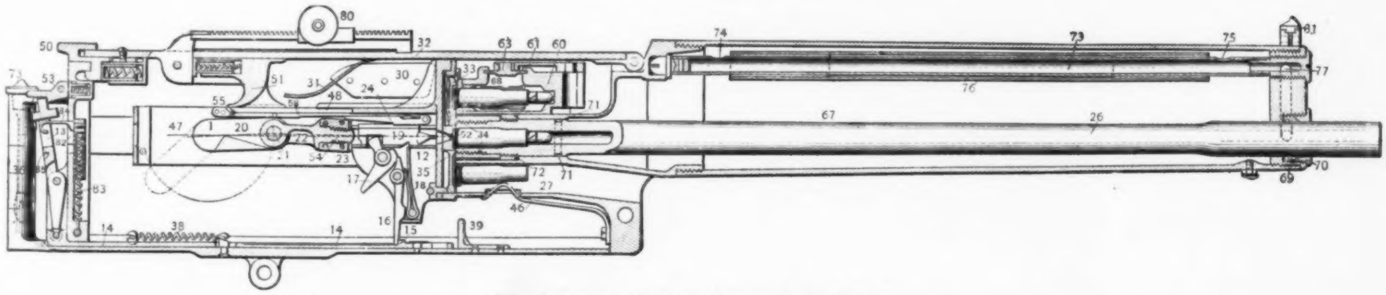


Fig. 2.—Longitudinal Section on Axis of Gun.

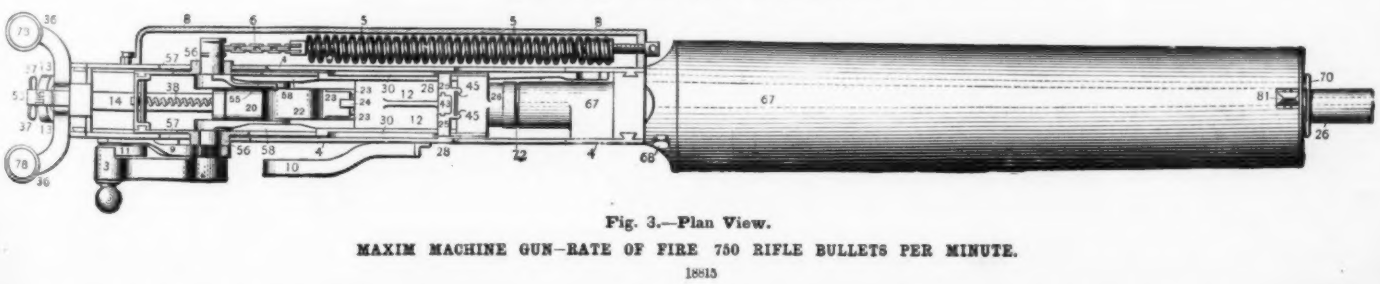


Fig. 3.—Plan View.

MAXIM MACHINE GUN—RATE OF FIRE 750 RIFLE BULLETS PER MINUTE.

minute, 34; number of rounds fired in three minutes, 83; time to dismount and replace, 2 minutes 4¼ seconds.

Hotchkiss—Number of rounds fired in one minute, 28; number of rounds fired in three minutes, 83; time to dismount and replace, 1 minute 37¾ seconds.

Skoda 3 pounder—Number of rounds fired in one minute, 24; number of rounds fired in three minutes, 55; time to dismount and replace, 33¾ seconds.

Sponsel—Number of rounds fired in one minute, 24; number of rounds fired in three minutes, 73.

Maxim-Nordenfelt—Number of rounds fired in one minute, 20; number of rounds fired in three minutes, 65; time to dismount and replace, 3 minutes 33¾ seconds.

It will be noticed that the Maxim-Nordenfelt gun required a longer time to take apart and replace parts than did the others. This was due to the fact that one of the bolts became jammed, and a wrench had to

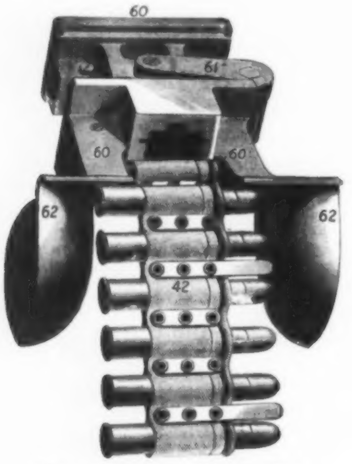


Fig. 4.—Feed-Box, Maxim Gun.

be used to loosen it. In the 15 seconds' trial the Driggs-Schroeder fired nine shots, the Sponsel eight, the Hotchkiss six, the Maxim-Nordenfelt seven and the Skoda eight. It is considered the Driggs-Schroeder gun showed the best results in these trials, although in the tests of last November the Hotchkiss gun was awarded the palm of slight superiority over the Driggs-Schroeder. The Driggs-Schroeder gun is manufactured by the firm of Cramp Brothers, of Philadelphia, so that it represents a purely American manufacture.

At the conclusion of the 100-round trial of the Hotchkiss gun the metal near the muzzle showed a temperature of about 600° F., but the heat at the breech was not sufficient to explode a cartridge which was inserted in the breech and allowed to remain there for four minutes.

In actual conflict the speed of fire would not be so great as in this test, which did not aim at accuracy; but with a practiced gun crew, from 20 to 25 shots per minute would be possible. If an approaching torpedo boat were discovered at a distance of say a mile and a half, it would take at least two minutes and a half to get within the firing range of its torpedo. During this time a single 6-pounder could rain 50 or 60 shells upon it, and in the case of a ship like the "Indiana," which carries ten of these guns on a broadside, the torpedo boat would be exposed to a storm of some 500 or 600 shells, each of which could penetrate four or five inches of steel at the muzzle.

Truly, the torpedo boat has found its effectual answer in the rapid-fire gun.

Fully Automatic Maxim 9-pounder.

The remarkable 9-pounder Maxim gun shown in the accompanying illustration should, strictly speaking, be treated in the following chapter under the head of machine guns, for its completely automatic action and its remarkable rapidity of fire give it many of the characteristics of that type. Its size and power, however, entitle it to rank with the Hotchkiss, Driggs-Schroeder and other light rapid-firers and render it an ideal weapon for "stopping" torpedo boat attacks, or protecting a mine-field against countermining operations. The gun is provided with a hopper feed and is capable of firing 60 rounds per minute. This gun and all of its class are worked by the recoil of the barrel. When the arm is loaded and the breech closed, the trigger is pulled and the barrel recoils, taking with it the breech-block, the energy of the recoil being checked by a hydraulic buffer, and the barrel returning into the firing position by the action of a powerful spring. The breech remains closed during the recoil and also during the forward movement of the barrel, and it is not opened until the barrel has nearly reached the firing position. By this means the breech is closed long enough to allow the gases to escape. The cartridges, which in this case are 3 feet long, are placed in a magazine on the top of the barrel, and at each discharge the lowermost cartridge is thrown into a tubular carrier. The tubular carrier falls by the weight of the cartridge, and when opposite the barrel springs rapidly forward, throwing the cartridge into the chamber and liberating the breech-block. The carrier, being now relieved of the weight of the cartridge, rises again into position opposite the lowermost cartridge in the magazine. At each discharge the carrier is thrown back against the action of the powerful spring. It might be said that the carrier is in a cocked position after each discharge and remains so until the cartridge falls down into line with the barrel, when it is liberated and the spring projects the cartridge into the chamber with great force. This arm is particularly well adapted for defence against torpedo boats, as it gives the gunner an opportunity for delivering a considerable number of shots in rapid succession without any assistance. Moreover, when the gun becomes heated, it is not necessary that the cartridge shall remain in the chamber while the gunner is watching for a torpedo boat. The cartridge being in the carrier, it is only necessary to allow it to fall in position, when the gun is instantly loaded and may be fired inside of a second.

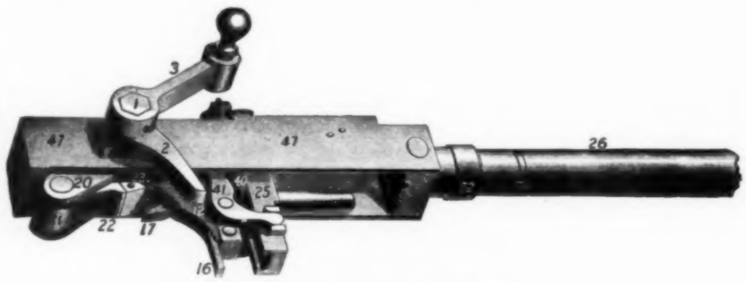


Fig. 5.—Recoiling Portion of Gun.

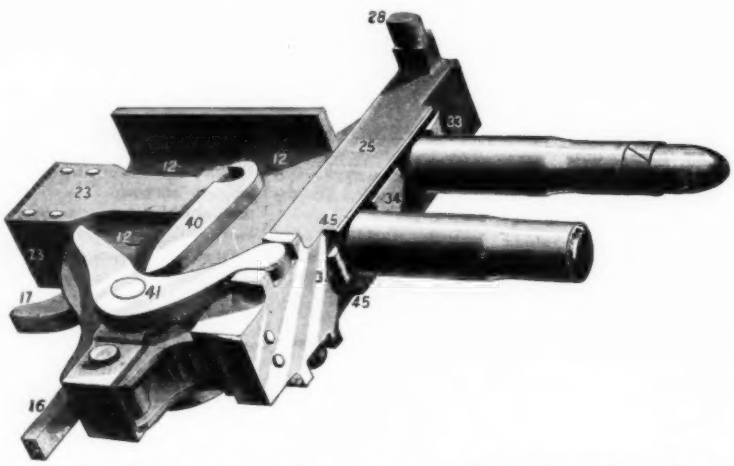


Fig. 6.—Removable Breech-Block, Cartridge-Carrier and Lock—Maxim Machine Gun.

Hotchkiss 2-pounder Mountain Gun.

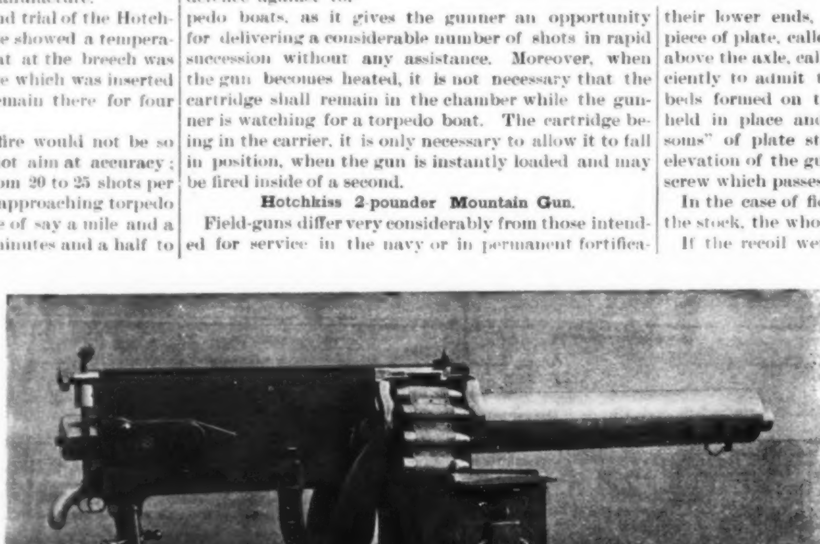
Field-guns differ very considerably from those intended for service in the navy or in permanent fortifications. The rough service to which they are liable, the difficulties of transportation, and the impossibility of carrying out elaborate repairs in the field, call for a special design of gun. Hence the field pieces are short and light, their mechanism is simple and quickly repairable, and they are mounted on carriages which can serve as transportation carriages when the gun is limbered up, and as gun mounts when the piece is in action. A field gun-carriage consists of a pair of massive wheels, a stout steel axle, the "stock" consisting of two pieces of plate steel, called the "flasks," which are carried at their forward ends upon the axle and converge at their lower ends, where they are united by a solid piece of plate, called the "tail-plate." The upper ends above the axle, called the "cheeks," are separated sufficiently to admit the gun, which rests in trunnion-beds formed on their upper surfaces. The flasks are held in place and stiffened by three or more "transoms" of plate steel, to which they are riveted. The elevation of the gun is accomplished by an elevating-screw which passes through the middle transom.

In the case of field-guns which are rigidly seated in the stock, the whole gun carriage recoils.

If the recoil were not checked in some way, much valuable time would be lost in returning the gun to battery, hence all field guns are provided with some form of brake. The simplest of these is a rope lashing the wheels to the carriage. Another is a shoe, which fits under the wheel and is chained to the gun stock, after the fashion of the shoe-brake used on the stage coach. Hotchkiss uses on some guns a conical friction brake, which tightens on the nave of the wheels. Col. Buffington, United States army, has designed a brake which consists of a shoe on the wheel, which is attached by an elastic extensible rod to the axle, eccentrically to the wheel.

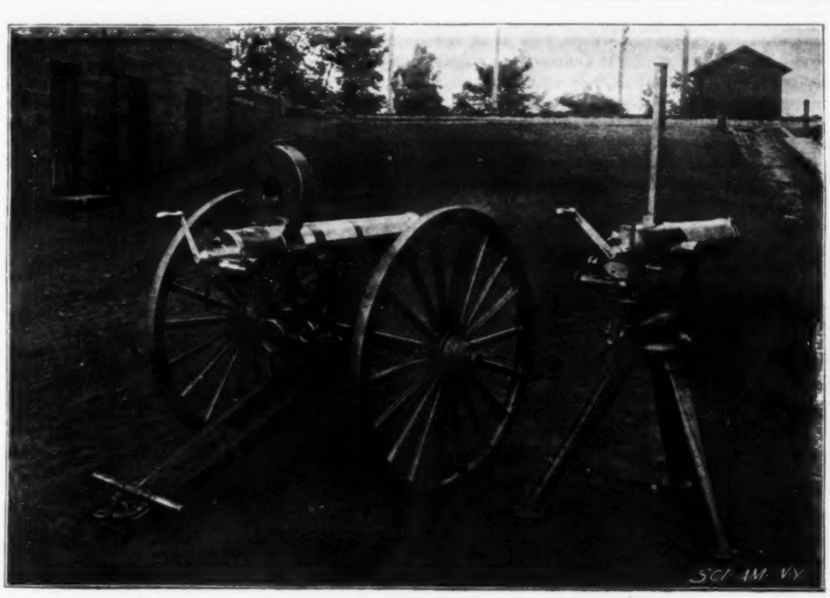
The training of field-guns is accomplished by moving the tail of the stock to right or left. For transportation the gun-carriage is ordinarily converted from a two-wheeled into a four-wheeled one by attaching to it a two-wheeled "limber," which contains the ammunition and is provided with shafts for the draught horses.

The 2-pounder gun, herewith illustrated, is provided with a pair of mule-shafts, which can be attached direct to the gun-carriage, and the tread of the wheels is so narrow and the


MAXIM 1¼-INCH AUTOMATIC MACHINE GUN—FIRES 300 ONE-POUND SHELLS PER MINUTE, VELOCITY, 1,800 FEET PER SECOND. PENETRATION, 2¼ INCHES OF IRON.

whole outfit so light (440 pounds) that a single mule can drag the gun on the narrowest trails and across very difficult country. The gun is also designed to be carried by pack animals through mountainous country in the manner shown in the accompanying cuts. Four mules are required, one to carry the gun, one for the carriage and two for the ammunition.

This handy little weapon has already seen active service in the United States army, where it has been used in the Indian wars at ranges of from 500 to 3,000 yards with great effect.



GATLING GUNS WITH DRUM AND GRAVITY FEEDS.

Rapid-fire Field-Guns with Recoil Mechanism.

In the field gun just described, the gun is fixed to the carriage and the two recoil together. This necessitates delay in wheeling the carriage back to the firing position. The automatic recoil mounts, which have increased so greatly the speed of fire in naval guns, have also been applied to field-guns with gratifying results. The mount and carriage of the 3-inch rapid-fire field-gun herewith shown were designed by Prof. P. R. Alger. The gun is carried in a recoil-cylinder (1) into the piston of which (2) it is screwed by means of a thread cut upon the forward end of its jacket. The cylinder is closed by front and rear glands (3, 4), and within it are the usual coiled spring and mixture of glycerine and water. Below the cylinder is an elevating arc, 5,

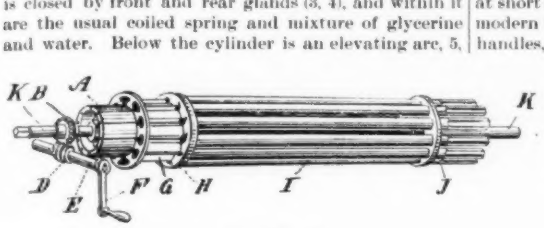


Fig 1

which is operated by a worm at the forward end of the elevating shaft, which is seen in the larger engraving just below the breech of the gun. The tail piece is provided with a tail wheel and a downwardly projecting "spade." When the gun is being moved, the tail wheel is down, as shown in the cut, but when it is in action, the wheel is thrown up and the tail piece rests upon a downwardly projecting shoe, which is driven into the ground by the recoil of the gun, and serves to hold the carriage stationary. The breech-mechanism is of the Fletcher rapid-fire type, and the piece is thus provided with all the advantages of a fixed rapid-fire gun. The gun fires a shrapnel shell weighing 13¼ pounds, and 32 rounds of ammunition are carried on the carriage in four boxes, two on each side. The weight of the gun, including the recoil cylinder, is 530 pounds, and the complete gun, carriage and ammunition weigh 1,830 pounds.

MACHINE GUNS.

It will doubtless have been observed, during our brief review of the various types of ordnance, that the rapidity of fire of the different weapons increases almost in the inverse ratio of their weight and size. From a rate of one shot in two or three minutes in the 12 and 13-inch guns, and in a minute to a minute and a half in the 8-inch weapon, we have seen the speed rise to six or seven shots per minute in the 6-inch rapid-fire gun, fifteen shots in the 4-inch, and twenty-five shots in the little 6-pounder guns.

The highest development of speed is obtained in what are known as machine guns, that is guns in which the operations of feeding, loading, firing and discharging the empty cartridge shells are all performed by the gun itself. Here there is a sudden jump from twenty-five rounds to one hundred and fifty rounds per minute for the 6-pounder guns, while in the machine guns, firing the regulation rifle bullets of between one-quarter and two-fifths of an inch diameter, the speed of fire has run up as high as a thousand shots per minute.

The awful destructiveness of these weapons in the hands of a cool and accurate marksman renders them at short ranges by all means the most deadly engines of modern warfare. The operator has simply to grasp the handles, keep his finger upon the trigger, and swing the gun to and fro as a fireman handles the nozzle. He is able to pour upon the enemy a literal stream of bullets, and there is not a body of soldiers in the world that could charge with the remotest chance of success against a position defended by a few of these diabolical weapons.

The Maxim Automatic Machine Gun.

The Maxim machine gun is one of the best known and most successful in the world, and it is to be found in the army and navy service of all the leading powers.

The gun practically consists of two portions—a recoiling and a non-recoiling portion. The recoiling portion embraces the barrel, the lock, the crank, the breech-block, and an inner frame with guides and bearings on which the said mechanism operates. The recoiling portion is, in reality, the gun proper. The outer or non-recoiling portion may be justly considered the carriage on which the gun operates.

The accompanying illustrations will assist in making clear the very ingenious mechanism of this type of gun. Figs. 1, 2 and 3 show respectively a diagram of the non-recoiling portion of the gun, a longitudinal section along the axis and a plan view with the cover removed. Fig. 4 shows the feed-box, Fig. 5 the recoiling portion of the gun and Fig. 6 is a view of the portion known as the bolt.

All the parts shown in full lines in Fig. 1 remain stationary when firing, with the exception of the outside crank arm or elbow lever, 2, 3, which is fixed to the crank wrist or shaft and forms a part of the recoiling portion, or gun proper, which is mounted inside of the gun frame, 4, in such a manner that when fired the recoil moves it back about one inch.

On the left hand and outside of the gun, or at the side opposite the crank, 2, 3, there is attached to the crank shaft, 1, a spiral spring, 5, by means of a chain, 6, and a small fusee, 7, as shown in dotted lines.

In Fig. 2, the spring box, 8, which contains the spiral spring, 5, is shown with the top removed, displaying

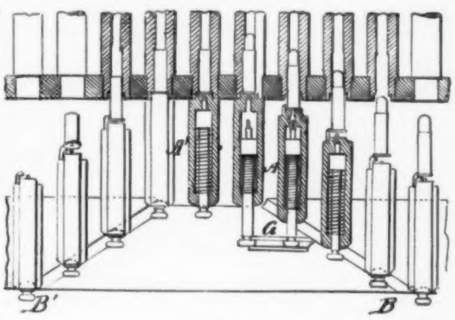


Fig 2

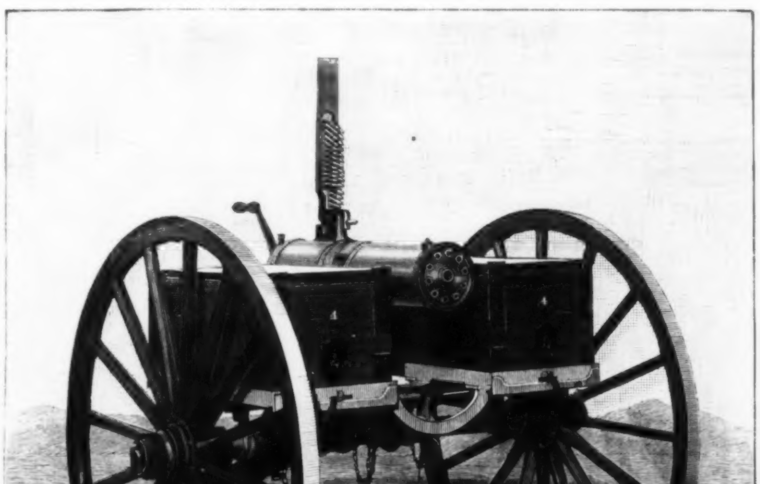
the said spring with its chain connection to the crank shaft, 1.

When the gun is fired, the arm or cam, 2, of the crank, 2, 3, which belongs to the recoiling portion, is brought in violent contact with a stationary point of resistance, 9, fixed to the gun frame, 4, the effect of which is to forcibly turn the crank shaft, 1, and cause the crank handle or arm, 3, to strike a buffer spring, 10, held outside the gun frame, so that, when the crank handle, 3, is resting on the buffer, 10, the spiral spring, 5, is not only extended one inch by the recoil, but the winding of the chain on the fusee causes a still further elongation.

Thus when the crank handle, 3, has been brought to a state of rest on the buffer, 10, the action of the spiral spring is first to pull the barrel and the whole recoiling portion back into firing position, and then to turn the crank to restore the bolt to firing position. As the crank handle is brought back to this position it strikes the dead stop, 11, which is pivoted to the gun frame and rocks on its pivot to receive the blow in such a manner as to prevent all rebounding.

In the longitudinal central section, Fig. 2, all the parts are in the positions of "ready" for firing on pulling the trigger. The lock employed is very similar to that used in the old fashioned single barrel pistol, namely, a firing pin, a main spring, a hammer and a sear. All these parts are mounted in the lock or bolt, 12.

When the upright trigger, 13, placed between the vertical handles, 36, is pressed, the rod, 14, is drawn backward and its projection, 15, engages the lower end of the sear, 16, thus releasing the hammer, 17, and the main spring, 18,

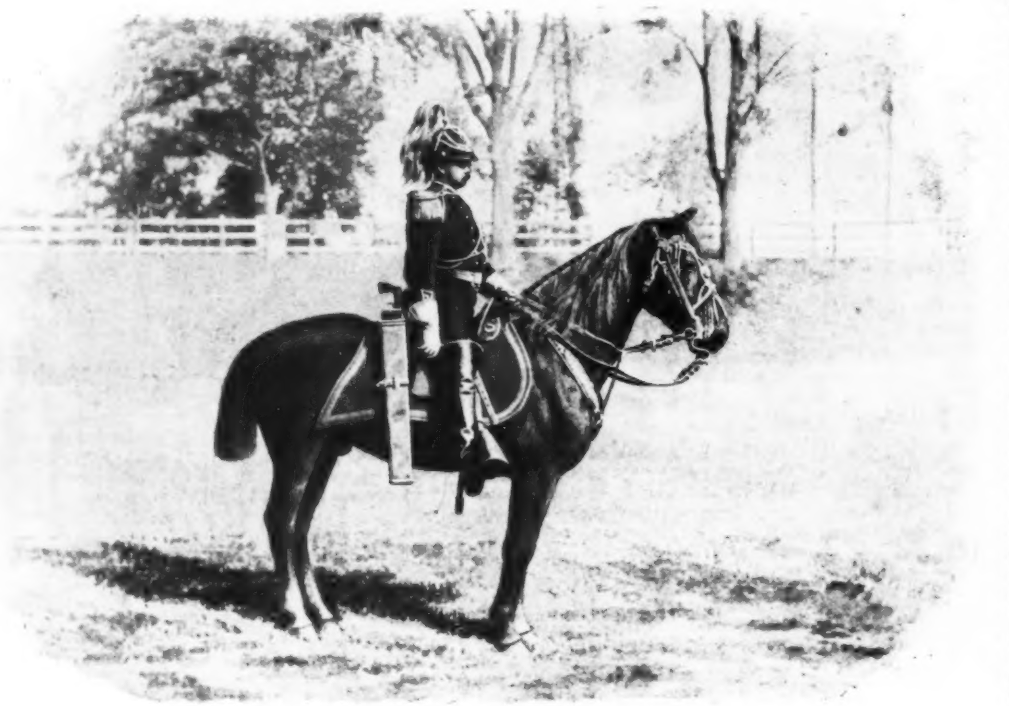


FRONT VIEW OF GATLING FIELD-GUN PROVIDED WITH BRUCE GRAVITY FEED. RATE OF FIRE 600 TO 1,200 SHOTS PER MINUTE.

then throws the firing pin, 19, violently forward to strike the primer and explode the cartridge. A spring, 38, returns the trigger and trigger rod to the cocked or freed position on removing the pressure.

All the operations of the breech mechanism are effected by the reciprocating movements of the outside crank, 2, 3.

The gun crank has an arm, 20, which is inside the gun frame, 4, and stands at right angles to the outside crank arm, 2. To this arm, 20, is pivotally attached the rear end of a connecting rod, 22, 23, the part 23 of which straddles and is pivoted to the breech-block, 12. Therefore, when the outside crank is turned forward, the inner crank arm, 20, is thrown downward and backward, as shown in dotted lines, Fig. 2. The part, 23, of the connecting rod is thus brought in contact with the tail of the hammer, 17, pressing it down, drawing back the firing pin, and compressing the mainspring until the sear, 16, engages a notch in the hammer and a safety sear, 24, engages a notch in the firing pin. At the same time the breech-block is withdrawn from the barrel, the empty cartridge case extracted, a fresh cartridge drawn from the belt, the carrier, 25, lowered, and the live cartridge brought in line with the barrel, 26, and the empty case in line with the discharge pipe, 27.

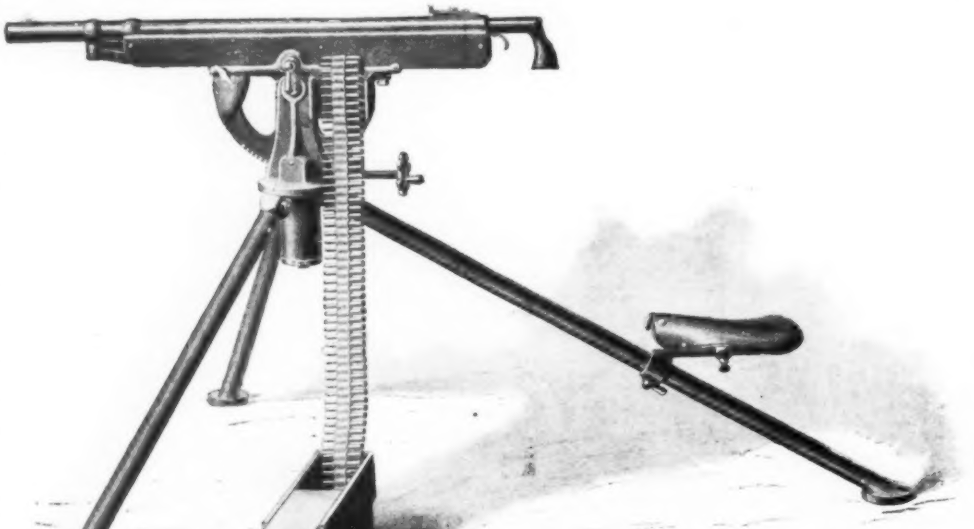


COLT GUN CARRIED IN BOOT BY CAVALRYMAN.

Projections, 28, on the carrier, 25, during the recoil and the opening of the breech, slide on cams, 30, on the frame, 4, whereby the carrier is held up until the empty case is extracted and a fresh cartridge drawn from the belt. The lowering of the carrier is then effected by gravity, assisted by a spring, 31, attached to the inside of the cover, 32, of the frame, 4. The carrier is guided and held steadily in its forward movements by the projections, 28, which slide in contact with the under surfaces of the cams, 30, until the breech-block is home. The carrier, 25, has spring catches, 33, 34 and 35, which with its grooved side flanges hold the live cartridge and the empty case in their proper places in the carrier, as is well shown in Fig. 6.

Cams, 40, in the closing of the breech, act on other cams on a lever, 41, to lift the carrier, 25. As the carrier rises, the spring catch, 33, yields and passes over the head of the loaded cartridge, in a belt, 42; the spring catch, 34, also passes over the head of the cartridge in the barrel, and the spring catch, 35, passes over the head of the empty cartridge case in the tube, 27, the carrier freeing itself from the empty case and at the same time taking firm hold of the fresh cartridge in the belt.

Grooves, 45, in this carrier, 25, are made to fit the flanged head of the cartridge, so that when the carrier rises, the cartridge is seized at both sides of the head, and while thus firmly held, the cartridge is extracted from the belt, performs its backward and forward movement with the breech-block, and enters the barrel of the gun with unerring accuracy; its empty case is extracted therefrom, and it again retreats and advances with the breech-block to be delivered into the discharge pipe, 27, where it is held by a spring, 46, until thrust out by the succeeding empty case.



COLT AUTOMATIC GUN ON TRIPOD, TAKING FEED DIRECT FROM AMMUNITION CASE. RATE OF FIRE, 400 SHOTS PER MINUTE.

The firing pin, 19, slides between guides in the breech block, and can strike the cartridge only through a hole, 52, and the carrier, 25; therefore, it can fire the gun only when the carrier is at the top of its stroke and the breech is closed, as shown in Figs. 2 and 3. The safety sear, 24, also secures the gun against firing until the breech is closed, by which action in the rising of the connecting rod, 22, 23, the sear is lifted, thereby releasing the firing pin. There is also a small safety catch, 53, which may be dropped down when the firing has taken place, and thus secure the trigger against being pulled until the catch is again lifted and thrown back by hand for that purpose.

In the continuous working of the gun, the empty cases are thrust one after another into the tube, 27, and are ejected therefrom with considerable force by the impact received from each succeeding case as it enters the tube.

The crank shaft, 1, is supported in bearings, 56, which are formed on the inner recoiling frame, 47, and extend through slots, 57, in the outer gun frame, 4, these slots being of sufficient length to permit the required recoil of the frame, 47, and its connected mechanism.

When the breech is closed the crank arm, 20, is slightly above its forward dead center, and bears against stops, 58, on the recoiling frame, 47. Therefore, during the period of explosion, the breech-block is firmly locked to the barrel and supported against the force of the explosion, so that the barrel, the crank, and the frame, 47, or the whole recoiling portion of the gun, will recede together until the crank arm, 2, strikes the point of resistance, 9, as above described, which throws the crank forward, opening the breech, at first slowly and then more rapidly, as the recoil advances. Thus the empty cartridge case is started from the barrel of the gun, at first very slowly, as is in like manner the live cartridge from the belt. By far the larger portion of the time between discharges is consumed in the opening of the breech, so that ample time is allowed for the pressure of gases to escape from the barrel before the breech-block is withdrawn from it.

The feeding of the cartridges into the gun is accomplished in the following manner: The cartridges are placed in the belt, 42, formed of two pieces of tape fastened together by eyelets and brass strips. The belt is made thick at the edge next the bullets by being folded over a cord, as shown, so that the cartridges may lie even in their magazines, while every fourth brass strip is made to project beyond the bullet edge of the belt a distance equal to that of the bullets, thus rigidly maintaining in the magazine the exact position of the cartridges in the belt.

The gun frame, 4, has firmly attached to it a cooling chamber or water jacket, 67, through which the barrel, 26, is arranged to slide longitudinally. The water jacket holds when full about 2½ quarts, and is filled through a hole at its rear end, which is closed by plug, 68.

By taking hold of the handles, 36, the gun may be pointed in any direction and controlled as freely as the discharge pipe of a common fire engine hose, while the thumbs fall naturally into the required position for the instantaneous manipulation of the trigger. Thus a stream of bullets is under the perfect control of the gunner, and may be directed instantly at any desired angle of elevation or depression or spread over any area. By means of sights, 80, 81, as accurate aim may be taken and as good a target made as with any rifle. The rapidity of fire of the gun ranges from 600 to 700 shots per minute, according to the type of cartridge used.

The Gatling Gun.

It was as far back as 1861 that Dr. Richard Jordan Gatling, who is a native of Hartford County, North Carolina, invented the machine gun which has rendered him famous the world over. Although he was born as early as the year 1818, Dr. Gatling enjoys today the best of health, and is a familiar figure in the business circles of New York City.

The Gatling gun is composed of a series of barrels, I (see Fig. 1, on page 21), grouped around a central shaft, K. There are usually ten barrels, but occasionally only five or six are employed. They are held in place by two barrel-plates, J, H, which are keyed to the shaft, one at each end. Immediately to the rear of the barrels is

a "carrier-block," G, which is keyed to the shaft, K, and is provided on its face with grooves which form extensions of the barrels, and receive the cartridges from the feed and guide them while they are being thrust into the barrels by the bolts. Immediately to the rear of the "carrier-block" is another cylinder called the "lock-cylinder," [illegible] It is attached to the central shaft, K, and in its surface are cut ten guide ways for a series of ten bolts corresponding to the grooves in the carrier-block. The bolts slide backward and forward and serve to open and close the breech and fire the cartridges. The central shaft may be operated by means of a hand-crank, F, the worm, D, and worm-wheel, B, if slow motion is desired; and extremely rapid fire may be secured by placing the crank directly on the end of the central shaft, K. The shaft, barrels, etc., are mounted in a frame and covered by a bronze casing to keep out the dust.

Each barrel has its own bolt, and each bolt is provided with a firing pin, an extractor for withdrawing the empty cartridge case, and a projecting lug which fits a groove cut in the casing. The groove is elliptical, and its form is such as to cause each bolt to perform one reciprocal movement for each revolution of the shaft and barrels.

Now, when the operator turns the crank, the barrels, carrier-block and lock-cylinder, being all keyed to the shaft, are rotated together in a fixed relative position, the casing remaining stationary. As the bolts are carried round in the lock-cylinder, their lugs follow the cam-groove in the casing (which does not rotate), and they are thrust forward in the downward half of their revolution and drawn back in the upward half.

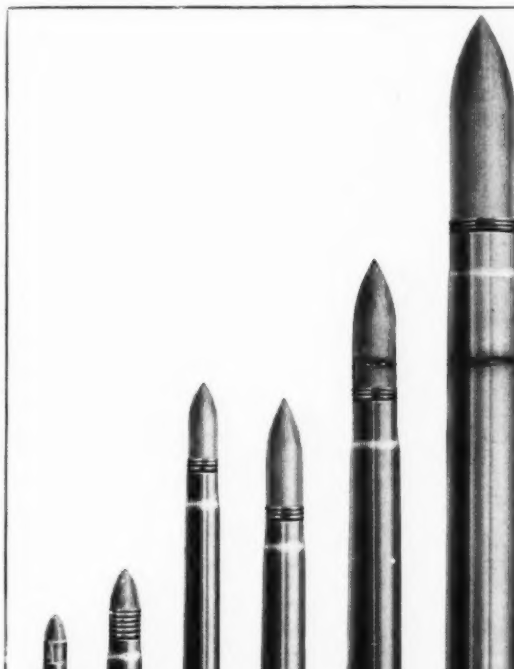
In the diagram, Fig. 2, which shows the action of the firing mechanism, the lock-cylinder and the breech of the ten barrels is supposed to be cut through and laid open on a plane surface. A B represents the right half of the cam groove and A' B' the left half. At the point, B', when the bolt is fully withdrawn, the cartridge drops from the feed into the grooves in the carrier-block between the bolt and the breech of the barrel. As the rotation continues the bolt is pushed forward by the engagement of its lug in the cam-groove, B A, and thrusts the cartridge into the barrel. At the point, R, the head of a firing-pin, which is carried within the bolt, is retained by a groove, the bolt still moving forward, thereby compressing a spiral spring and cocking the firing-pin. By the time that the bolt has thrust the cartridge home in the barrel, the head of the pin has reached the end of the groove, R, and, being now released, it is carried forward by the spring and fires the cartridge. The further rotation of the shaft causes the cam-groove to draw the bolt to the rear, the cartridge being withdrawn by means of an extractor-claw at the forward end of the bolt.

As there are ten barrels, a rotation of once a second would enable the gun to fire 600 shots a minute, and this speed may be easily doubled if so desired.

Three systems of feed are used, both of which are shown in the accompanying illustrations. The first consists of a drum, which is attached to the gun just above the carrier-block. The interior of the drum is divided by a spiral strip of metal which begins at the center and finishes at the mouth of the drum. A set of radial arms are placed within the drum, and by their rotation serve to force the cartridges along the spiral from the center to the mouth at the circumference. The arms are engaged by the grooves on the carrier block, and as they are carried round a cartridge is dropped into each groove of the block. This feed is shown on the field-gun in the cut at the top of page 21.

In another system shown on the same page the cartridges fall by gravity down the grooves of an upright guide in which they are held by the rims of the cartridge-cases. The latest feed consists of strips of metal, with tongues punched in them, which embrace and hold the cartridges. The strips are fed to the gun face down, that is, with the cartridges on the under side, and as the carrier-block rotates it detaches the cartridges and carries them one by one into the gun.

The Gatling gun is simple, reliable and durable. The number of barrels used, and the use of but one barrel at a time, have a tendency to prevent overheating, thus giving great endurance, as was proved in a recent trial before a naval board, in which over 100,000 cartridges were fired, of which over 63,000 were fired without stopping to wipe out or clean the barrels. At the end of the 63,000 rounds the gun was found to be in good condition.



1. 1-pounder. 2. 2½-pounder. 3. 3-pounder. 4. 6-pounder. 5. 9-pounder. 6. 33-pounder 4-inch gun.

FIXED AMMUNITION FOR RAPID-FIRE GUNS.

The following are the particulars of the army Gatling gun:

Bore	0 30
Length of barrel	32 inches.
Weight of bullet	220 grains.
Powder charge, smokeless	38 to 42 grains.
Muzzle velocity	2,000 f. s.
Penetration	48 inches of wood.

The Colt Automatic Gun.

We close the present chapter on machine guns with a brief description of a weapon which has already done good service in the operations on the south coast of Cuba — the Colt automatic gun. Like the Maxim machine gun, it is fully automatic; all that is necessary, when it is once started, being to hold the finger on the trigger, when the gun will continue firing at the rate of 400 shots a minute until the cartridge box is empty. Like the Maxim, it consists of a single barrel, but, owing to the thickness of the barrel, it does not heat as rapidly as some of the single barrel guns, and the water jacket is not necessary.

The gun itself consists of a stout barrel attached to a breech casing, in which is carried the mechanism for charging, firing and ejecting the shells. The belts are coiled in boxes, or they may rest on the ground. When attached to the casing, the boxes move with it, so that the vertical or horizontal movements of the gun will not affect the supply of ammunition. The gun is operated by the pressure of the powder gases in the barrel after the projectile has received its maximum velocity. This is done without injuring either its range or its penetration. In the barrel to the rear of the muzzle is a small radial vent, which opens downward from the bore. This is closed by a piston which fits in the gas cylinder that surrounds the outer edge of the vent. The piston is pivoted to a gas lever in such a way that the latter adjusts itself to the gas cylinder. The lever swings in a vertical plane. To operate the gun, the feed belt is put in and the lever is thrown down and backward as far as it will go. It is only necessary to do this once by hand. The lever is then released and the spring causes it to move forward, close the vent and transfer the cartridge from the carrier to the barrel. The same movement cocks the hammer and closes and locks the breech. The shot is then fired by pulling the trigger. After the bullet has passed the vent and before it leaves the muzzle, the powder gases, expanding through the vent, work the piston and the gas lever, which act on the mechanism so that the breech is opened, the shell is thrown out and another one is fed into its place. The gas lever in returning forces home the cartridge in the barrel and closes and locks the breech. If the trigger is held instead of being released, the operation is repeated as long as the cartridges are supplied to the gun. It will be thus seen that it is strictly an automatic gun. The manufacturers state that, as the action is due directly to the pressure of the gases on the lever, instead of the recoil of the barrel, storage springs of greater strength than those usually employed may be used. There is a safety lock that holds the hammer fast, so that it will not strike the firing pin when a loaded cartridge is left in the gun. The hammer is also used as a piston for an air pump. This forces air into the chamber in the barrel, which carries away any residue or unburnt powder. All of the working parts of the gun are readily accessible. Owing to its lightness, the gun can be handled easily by one man, the operation of the gun being practically like firing a pistol.

The gun is mounted pivotally on a light tripod stand. It is elevated and depressed by means of a worm engaging an elevating arc. A small saddle for the gunner is clamped to the rear leg of the tripod, and a small hand wheel below the gun serves to operate the elevating gear.

The particulars of weight, penetration, etc., of this remarkably compact weapon are as follows:

Bore	6 mm. or 0·2362.
Length of barrel	28 inches.
Weight of bullet	112 grains.
Weight of powder	33 grains (Troisdorf, smokeless).
Muzzle velocity	2,500 f. s.
Muzzle penetration	60 inches pine.
Speed	400 to 500 shots per minute, regulated in construction of gun, according to requirements.
Weight of gun only	40 pounds.
Or complete with tripod and mount	94 pounds.
Weight of field carriage complete, gun mount, ammunition chests, cartridges, belts and feed boxes for 2,000 cartridges	230 pounds.

The small weight and bulk of the gun render it an ideal weapon for cavalry or for the operations of a naval landing party. For cavalry use it is carried with its folding tripod in a boot attached to the saddle, when it will reach only from the waist to the stirrup, or it may be strapped to the side of a pack saddle.

1. Armor-piercing steel shell. 2. Shrapnel. 3. Case shot. 4. Common shell. 5. Complete cartridge.

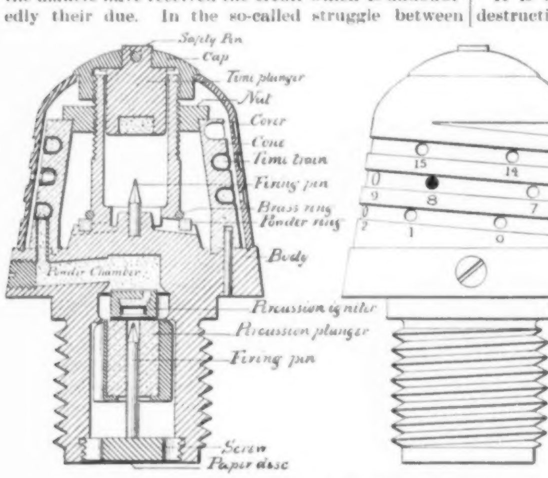
SECTIONAL VIEWS OF HOTCHKISS RAPID-FIRE AMMUNITION.

PROJECTILES.

THE new 16-inch, 125-ton coast-defence gun delivers its shells with an energy of over 64,000 foot-tons; that is to say, the energy embodied in the flying missile, if applied gradually as an upward thrust, beneath the keel of the battleship "Iowa," when she is resting in the dry dock, would be sufficient to raise her bodily six feet into the air. But the energy of the projectile is transmitted to a ship, not gradually, but in an instant of time, and, moreover, it is all concentrated at the moment of impact on a pointed head, which must, therefore, be made of suffi-

cient strength to deliver this enormous energy to the vessel's armor without suffering fracture or distortion.

Evidently, then, a modern projectile must possess extraordinary powers of resistance, combining in itself in an extreme degree all those elements of hardness and toughness which, as we have seen, are necessary in the metal of which high-powered guns are built up. Of late years there has been a vast amount of time and skill expended in the effort to produce armor-piercing shells that shall be capable of effectively developing the whole penetrative energy of the gun on the armor-plate, and it is a question whether the projectile makers have received the credit which is undoubtedly their due. In the so-called struggle between guns and armor, the projectile has of late years been the determining factor, and had it not been for the extraordinary quality of the projectiles which have been produced by Johnson, Wheeler-Sterling and others, coupled with the introduction of that most ingenious device, the soft metal cap, it is certain that the victory, as between guns and armor, would have lain with the plate. To-day the gun, with its soft-capped projectile, is supreme.



FRANKFORD COMBINATION (TIME AND PERCUSSION) FUSE.

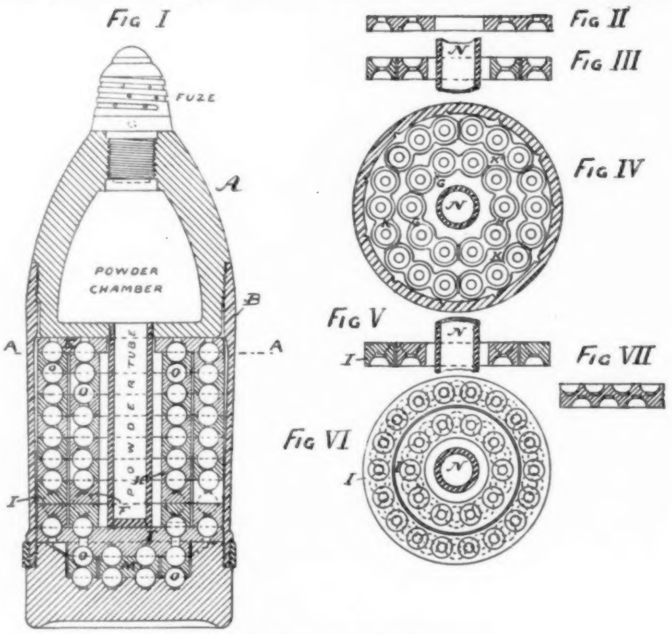
Solid Shot, Shell and Shrapnel.

Solid shot, except for the smallest arms, is rarely manufactured at the present day. What is called solid shot is not actually solid, but is made with a hollow core. Spherical shot, moreover, has disappeared with the smoothbore, and all shot and shell are formed with a cylindrical body and a pointed (ogival) head. In the days of wrought iron armor, shot was made of cast iron, and the projectiles of Major Palliser with a chilled head were fully equal to penetrating the best plates of that time. With the introduction of steel armor, however, it became necessary to find a tougher material than cast iron, and steel shot was tried with gratifying results. The supremacy of steel projectiles over steel armor has been maintained with occasional intermissions to the present day.

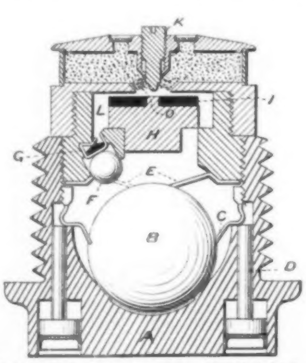
As we have already stated, shot is seldom made absolutely solid for the modern guns. If it were, it would be difficult to secure the high resisting quality in the material which is necessary. By casting the projectile hollow it can be so treated that all the strains can be removed and its toughness greatly increased. The best projectiles are cast of a special quality of steel with which is alloyed a certain amount of chromium to give it the necessary toughness, and then forged, annealed and carefully tempered. When the hollow shot is filled with a bursting charge of powder and provided with a fuse to ignite the charge it is known technically as a shell. The present aim of artillerists is to abolish the use of shot in favor of shell, for the reason that the widely spread destruction wrought by the many flying fragments of a shell is far greater than the local damage inflicted by the single solid projectile. The shot, with its small interior cavity, is of course stronger than the shell with its larger cavity and thinner walls. The problem is to produce a shell strong enough to hold together until it has passed through the armor, but with a large enough cavity to carry within it a powerful bursting charge. If the walls are made beyond a certain thickness, the charge will have to be reduced and may not prove to be powerful enough to rupture them. On the other hand, considerations of strength demand that the walls shall be heavy enough to carry the shell through the plate without parting. The solution of the difficulty is found in the use of high-explosive bursting charges. The French were the first to solve the problem with a substance called melinite; since that time many other suitable explosives have been invented and put into successful use.

The Delayed Action Fuse.

It is evident that the full destructiveness of a shell will only be realized if its explosion is delayed until it has passed entirely through the armor into the interior of the fort, turret or ship. This result is secured in some armor-piercing shell by relying upon the heat engendered by the passage of the shell through the armor, and in others by what is known as a "delayed-action fuse." This device, of which we show a vertical section herewith, consists of a hollow threaded case, A, which is screwed into the base of the projectile. It contains a spherical hammer, B, held down in place by two springs, C, whose lower ends rest in notches provided for the purpose, on the surface of B. In the base of the case, A, are bored out two small cylinders, in which work a couple of pistons, whose rods, D, extend up into the interior of the case, where they rest in contact with the holding-down springs, C. A threaded ferrule is screwed into the upper end of the case, and a suitable shelf within it serves to carry a plug, H, upon which rests a ring or washer, I, of specially prepared powder. A cap, provided with a central hole, O, is screwed on above the ferrule and in the cap is an ignition charge for exploding the powder in the shell.



THE FRANKFORD 5-INCH SHRAPNEL.



DELAYED-ACTION FUSE, FOR EXPLODING SHELL AFTER IT HAS PASSED THROUGH THE ARMOR.

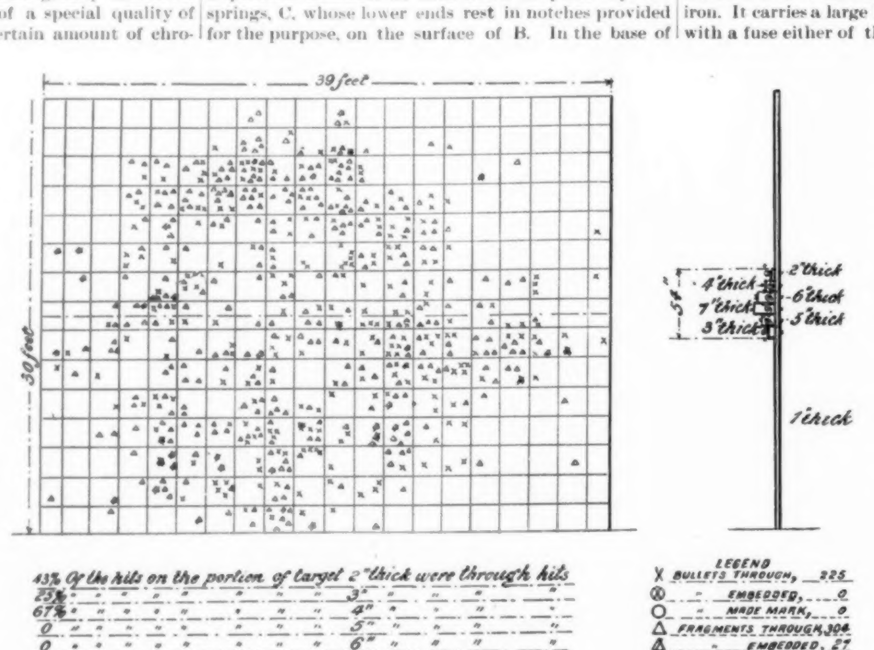
When the gun is fired, the pressure of the powder forces in the two pistons, and their rods, D, push the springs, C, out of the notches in the hammer, B, leaving it free to move forward at the moment of impact. When the shell strikes the armor, the hammer flies forward by its own momentum and strikes three steel balls, F, causing them to ignite a primer, G. The flame of the primer fills the cavity, L; but it is prevented from passing through O, to the ignition charge, by the fact that the plug, H, was driven forward at the instant the shell struck the armor, thereby closing the orifice. The flame of the primer sets fire to the washer of prepared powder I, which, as it is squeezed in tightly between two flat surfaces, can only burn from the edge inward. This causes a slight delay between the moment when the shell strikes the armor and the moment of explosion, the interval being the time taken by the washer, I, in burning from its circumference to the center hole leading to the ignition charge above it. The flame of the ignition charge explodes the powder in the shell. The delay is of course extremely slight, being only sufficient to allow the shell to reach the interior of the ship.

Shells are, broadly speaking, of three types: armor-piercing shell, common shell, and case shot, or shrapnel as it is now called. Common shell is made of cast iron. It carries a large bursting charge, and is provided with a fuse either of the time or percussion type. It is not intended for armor piercing, its destructive effects being due to the disruptive force of the explosion and the flying fragments of the shell. In the larger calibers the fuse is contained in a small case which is screwed into the base. In external appearance there is nothing to distinguish the common from the armor-piercing shell except the point, which is blunt in the former and sharply pointed in the latter.

Shrapnel is essentially the projectile of field artillery. It consists of a cast iron head and base, and a light connecting case, the interior of which is filled with balls of small caliber. It is exploded by a time fuse.

Manufacture of Projectiles.

There is, perhaps, no branch of the manufacture of war material that is guarded with so much secrecy as that devoted to the production of projectiles. Each maker has his own pet theories as to the proper composition of the



TARGET RESULTS OBTAINED IN GOVERNMENT TEST OF 5-INCH SHRAPNEL.

steel, the best methods of casting and forging, and above all are the secrets of tempering guarded with a jealous eye. The armor-piercing projectiles are cast head downward in a special mould, and if the point is to be chilled, a chill is first placed at the bottom of the mould. If forged steel shells are to be produced, the steel casting is made of considerably larger diameter than the finished shell, is cast solid, then reheated and hammered down until it is slightly larger than the finished diameter. Next it is put in the lathe, rough-bored, and pointed, and given a finishing cut. The cylindrical body of the shell is of slightly less diameter than the base of the ogival head. This enlargement is provided to afford a bearing surface for the forward end of the shell as it travels up the bore of the gun. The after part of the shell bears against and is centered in the gun by the rifling-band—a band of soft copper which is hammered into a groove that is cut around the shell a few inches from its base. The exterior diameter of the band is greater than the bore of the gun, and when the shell is rammed home, it fetches up with the band engaging the commencement of the rifling in the "compression slope." (See sectional view of the 12-inch gun, page 5.) When the gun is fired, the powder pressure expands the soft copper, forcing it into the grooves, causing the shell to follow the twist of the rifling. The result is that by the time the projectile leaves the muzzle it is spinning at the rate of seventy-two revolutions per second. The rapid rotation of the shell about its longer axis prevents it from "tumbling," that is, turning end over end in its flight. The copper band, by filling the grooves and the space between the shell and the bore, acts as a gas-seal, and serves in this respect the same purpose as the asbestos pad on the breech-block.

The shell is cut off to the finished length in a special machine. There are many processes of hardening: In one of these the shell is placed, head downward, in a bath of molten lead, and left there for four hours, the temperature of the lead being raised during the process from 500° to 1,300°. The shell is then withdrawn, sprayed with water, and finally placed in a bath which is prepared by a secret process. The base is then threaded for the closing screw plug, and the shell finally ground down to the finished dimensions in the grinding room.

The finished projectile is now ready for the test, and if it is up to contract requirements, it will penetrate the best armor plates of a thickness equal to $1\frac{1}{6}$ times its own diameter without cracking or suffering any deformation.

Shrapnel.

Shrapnel will play an important part in the field operations of the present war, and in order to explain fully the destructive character of this form of projectile we give complete illustrations of a 5-inch Frankford shrapnel, showing its construction, the method of controlling the explosion, and the wide area over which its effects are felt.

A modern shrapnel consists of a cast iron head and base, a central case, a large number of balls and separators, a powder chamber, and a fuse which may be set to explode the shell at any point in its flight or on contact.

The head, A, which is cored out to form a powder chamber, is bored and threaded to receive a Frankford Arsenal combination fuse. A central powder-tube is screwed into the base of the head and extends into the body of the shell, to insure a more complete dispersion of the balls and fragments of the shell.

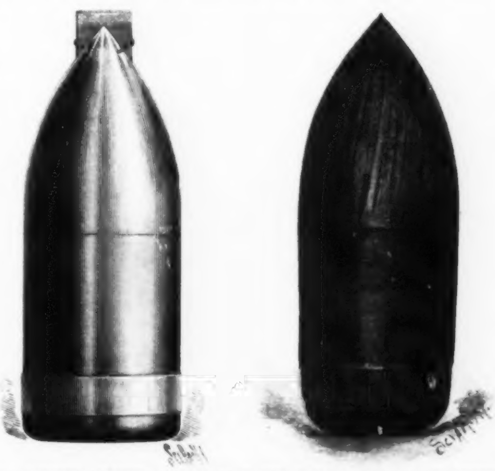
The case, B, Fig. 1, is a short length of steel tubing, threaded at each end to receive the head and base, and weakened, to insure fracture, by several longitudinal grooves cut on the inside. Within the case is the "filling," which consists of 280 lead balls, O, O, one-half an inch in diameter, arranged in circular layers and held in place by 59 cup-shaped cast iron separators (Figs. 2 to 7). The separators prevent deformation and motion of the balls within the case under the shock of discharge, and render the shell more deadly by increasing the number of fragments. The top separator, Fig. 2, has a flat surface, which bears against the base of the head, and the bottom separator has lugs which fit in recesses in the base and prevent rotation of the balls, etc., relatively to the shell.

The base is of cast iron and threaded to take the rear of the case; and at the point where the two are joined, the copper rotating-band is secured on the outside of the case.

Before the filling of separators and balls is placed in the case it is subjected to a pressure of 10,000 pounds to pack it thoroughly together and insure that the assembled shell shall act as one solid mass under the shock of discharge. The total number of balls, separators and individual pieces in the complete shell is 344.

The Frankford Combination Fuse.

The device for securing explosion of a shell is known as a fuse, and while of fuses there is an endless variety, the principles on which they act are simple and essentially the same. There are two types, the percussion and the time fuse. The former explodes the shell by the striking of a hammer upon a fulminate, the explosion taking place on the impact of the shell. The time fuse is operated by the action of a "time-train" of prepared powder, which is ignited by the firing of the gun, and reaches the exploding charge in the shell at a predetermined time after the shell has left the gun.



A 6-INCH JOHNSON SOLID SHOT WITH SOFT CAP, BEFORE AND AFTER PENETRATING 10-INCH RE-FORGED HARVEY PLATE.

The fuses are placed either in the head or the base of the shell; in the larger projectiles they are almost invariably in the base. The Hotchkiss percussion fuse is the standard type for the United States service, and the Frankford combination fuse is the service type for shrapnel. As the Frankford combination contains both a time and a percussion fuse, we have selected it for illustration.

It consists of a bronze body, threaded at the rear for screwing into the head of the shell. In the front portion is the time fuse, and the rear portion contains the percussion fuse. The most important element of the time fuse is the "time-train," a length of lead pipe, filled with mealed powder, which is wound spirally around a hollow cone of soft metal that rests upon and is attached to the bronze body of the fuse. The time-train has a regular rate of burning, so many inches corresponding to so many seconds of time. At its rear end it leads into an ignition powder chamber whose contents serve to explode the shell. The cone and time-train are inclosed in a brass cover and a cap, and the cover is indented with a spiral groove corresponding to that on the spiral time-train on the interior cone. The bronze case is extended within the cone to form a hollow cylinder, and at its forward end is carried a cylindrical plunger, which contains a fulminate in its base. The plunger is held at the forward end of the fuse by some small lugs which engage in recesses cut in the cover-cap. Behind the plunger is a firing pin. The plunger is secured to the cap during transportation by a safety-pin, which is taken out when the shell is inserted in the gun.

The percussion fuse consists of a percussion plunger in which is inclosed a firing pin, the plunger being normally at the forward end of the pin. Above the pin, and separated from it by a safety-disk of copper, is a primer, which communicates through channels cut in the surface of the plunger with the bursting charge of the shell.

The action of a time fuse is as follows: When the point at which it is desired to burst the shrapnel is determined, the time-train is pierced at the number—say 8—corresponding to the time in seconds which it will take the shell to cover the distance. The hole is punched through cover, time-train and cone at the 8 mark. The safety-pin is then withdrawn and the shell placed in the gun. At the moment of firing, the inertia of the time-plunger causes its supporting lugs to break, and it falls upon the firing pin and explodes the fulminate, the flame of which ignites a ring of compressed powder at the rear of the annular space within the cone. The flame of the burning powder passes through the hole already punched through the cone and ignites the time-train, which burns for 8 seconds, at the end of which time it reaches the powder chamber and ignites the charge. The flame from this passes down through the base of the fuse and explodes the charge in the shell.

When acting as a percussion fuse, the shock of discharge causes the percussion plunger to slide to the rear, exposing the point of the firing-pin. When the projectile strikes, the plunger and pin fly forward, exploding the primer.

At the moment of explosion the steel tube forming the body of the shell is ruptured and the balls and fragments are scattered, moving on with the velocity of the shrapnel plus that imparted to them by the force of the explosion. The fragments at once spread out in what is known as the "cone of dispersion," and the area of ground on which the fragments land will have the shape of an irregular oval. Experience has shown that the best point at which to burst a shrapnel is 6 yards above and 50 yards in front of the target.

We present an illustration of the effects of a 5-inch shrapnel tried in a government test against a target 30 feet high by 39 feet wide. The target was 194 yards from the muzzle, and to determine the penetration of the bullets and fragments, the center of the target was increased in thickness, as shown in the diagram. The destructive results are given in the tables on the diagram.

The Soft Cap for Armor-piercing Projectiles.

The present superiority of shot to armor is largely due to the simple expedient of placing a soft metal cap over the point of the projectile.

We present on this page an excellent half-tone engraving of one of the most successful penetrations of Harveyized armor-plate on record, which was made by a Johnson solid shot at the naval proving ground. The penetration of 10 inches of nickel-steel, face-hardened, reforged plate by a 6-inch shot, as shown at the point marked No. 3 in the engraving, is in itself a phenomenal performance; but when our readers learn that, after penetrating the plate, the shot passed through 12 inches of oak and three boiler plates $\frac{7}{16}$ inch thick, and was finally found 8 feet back in the sand and practically uninjured, they will understand how complete is the superiority of the best type of shot over the best type of armor to-day.

It is a matter of history that, just at the time when armor plate makers were

PHOTOGRAPH OF 10-INCH RE-FORGED HARVEY PLATE AND 6-INCH JOHNSON CAPPED SHOT AFTER COMPLETE PENETRATION. STRIKING VELOCITY, 2,502 FOOT-SECONDS. STRIKING ENERGY 4,595 FOOT-TONS.

discouraged by the ease with which the gun makers were able to penetrate the toughest nickel-steel, Mr. Harvey produced his brilliant invention for giving an intensely hard face to the plate, and succeeded in smashing up the projectiles at the moment of impact. Shots which theoretically should have passed clear through a Harveyized plate failed to do so, because their points could not hold together long enough to break in through the highly tempered face, which was made so hard that it could cut glass like a diamond point.

Subsequent to the appearance of Harveyized armor the makers of projectiles had been trying to produce a shot which should combine the necessary hardness and toughness to enable it to split open the hardened face and hold together until it had wedged its way through the body of the plate itself. Previous to the year 1896, a few of the best makers had met with partial success. The Holtzer shell in Europe and the Sterling-Wheeler in this country had succeeded in breaking up the face; but the effort proved too much for the shell, which collapsed before it could get entirely through the plate. This has been the case almost invariably when the improved, reforged, Harvey plate has been attacked. The result is shown very clearly in the case of shot No. 1 in the trials mentioned, when an 8-inch Holtzer shot, weighing 250 pounds, and fired with a velocity of 1,800 feet a second, entered the plate and broke up, leaving the point embedded.

For many months the reforged Haveyized plate held its superiority, and it looked as though the final victory in the long contest between shot and armor was to rest with the armor. The next move on the part of the artillerist was of a very extraordinary, but very successful kind. He placed a cap of soft steel over the point of the shot to protect it, and, paradoxical as it may appear, the soft cap enabled the shot to get through.

The part played by the cap may best be explained by a simple experiment which can easily be tried by any of our readers. An ordinary sewing needle may be driven through a copper cent piece by thrusting it through a cork until the point is flush with the bottom of the cork, placing it upon the copper cent, preferably over an anvil, and giving the head of the needle a sharp tap with a light hammer. The copper will be cleanly perforated. The surrounding cork holds the body of the needle in the line of the blow, so that its whole force is concentrated at the point. The action of the cap is somewhat analogous. It preserves the integrity of the point of the shot at the moment of impact, holding the material together until penetration through the hard face is effected. Moreover, the cap becomes fused by the heat of concussion and lubricates the point as it enters. After the face is broken through, the shot holds together by virtue of its peculiarly hard and tough composition, which is obtained by a secret process of manufacture.

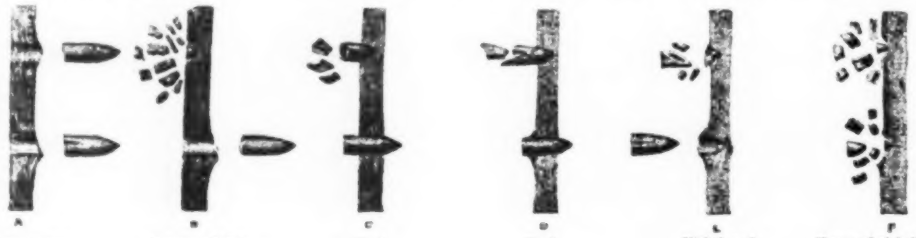
Referring again to the photograph of the plate, shot No. 2 represents a 6-inch 100-pound Johnson shot which was fired with brown powder at a velocity of 2,100 feet per second. It penetrated to a depth of 8 inches and communicated all of its theoretical capacity at that velocity, the rear portion of the shot breaking off and rebounding from the target. Mr. Johnson was confident that if the shot were given greater velocity, it would make a clean penetration, and accordingly a charge of 28 pounds of torpedo station smokeless powder was inserted for the next round. The shot, weighing 105·25 pounds, struck the target with a velocity of 2,505 foot seconds and an energy of 4594·8 foot-tons at a point 21·5 inches normally from the bottom and 32 inches from the left edge of the plate. The work of the shot, which passed through the plate practically uninjured, can best be given in the words of the official report:

Action of Projectile.—Projectile penetrated plate, backing, boiler plates, and was recovered 8 feet back in the sand, entire, with the exception of one-half of base broken off diagonally to the bandscore. The remaining portion of the shell was in excellent condition, with the point whole, the head slightly scored, increased in diameter at the bourrelet 0·15 inch, and in body 0·06 inch; length decreased 0·49 inch. Two small surface longitudinal cracks in the body 5·5 inches and 2 inches long, also two in the head 1·5 inch and 2·5 inches long respectively. Four fragments recovered; total weight, 95 pounds; weight of the shell proper, 85 pounds.

Effect on Plate.—Penetration complete; diameter of shot hole, 6⅛ inches; interior for about 3·5 inches rough, with fused metal; rest of hole smooth; all the interior coated with copper, probably from the rifling band. Diameter of splash and flaking 13 inches, ⅝ inch deep. The boiler plate backing was star opened to a diameter of 16 inches.

A comparison of the two cuts showing the projectile before and after firing will show the wonderful endurance of the shot. The deep scorings on the conical head were produced by the jagged edges of the hardened armor face, and the twist imparted by the rifling is plainly discernible. The corrugated recess at the base is the seating for the copper rifling band, which, as the report states, was sheared off in the shot hole, together with diagonal fragments of the base. At the time when it took place, this was by far the most brilliant performance of any shot in any country, and it was well calculated to carry dismay into the camp of the armor plate makers. Since that time the soft cap has been applied with great success to other projectiles, and the Wheeler-Sterlings, which hitherto failed to get through the plate unaided, have made successful penetration with the cap attached.

Incidentally it should be noted that the success of the second Johnson shot was only achieved by using a high velocity, considerably higher than the 2,000 feet per second which is obtained with the standard brown powder used for United States ordnance. Mr. Johnson is asking for 3,000 feet per second in order to develop the full potentiality of his solid shot; and it must certainly be admitted that the introduction of smokeless powder, with its higher velocities, would be an advance along the lines which are being universally followed by the gun makers of England and the Continent. The 10-inch Brown segmental wire gun now in course of construction by the government, and described on page 11 of this issue, will have a maximum velocity with smokeless powder of 3,000 feet per second, and would seem to be the natural counterpart of the capped shot.



A. Wrought iron. 1888. B. Compound plate. 1888. C. Steel. 1888. D. Steel. 1894. E. Nickel-steel. 1894. F. Harveyed nickel-steel. 1894.

The upper projectiles are Palliser chilled iron shells, and the lower are chrome steel.

ATTACK OF 6-INCH ARMOR-PLATE BY 4·72-INCH SHELLS.

ARMOR-PLATE.

For the beginnings of the armor-plate industry we must go back to the two great wars that occurred in the middle of the present century—the Crimean war of 1854 and the American civil war of 1861. It is true, there were earlier and abortive attempts to utilize armor as a protection against the fire of heavy guns; but it was not until the period mentioned that heavy armor began to come into general use and the great industry which it has introduced was permanently established. No account, however, of the development of armor plate would be complete that failed to make mention of the work of John Stevens, of Hoboken, N. J., who carried out long and costly experiments on the subject of armor and projectiles, in which it was proved, as early as 1841, that 4-inch wrought iron armor would keep out the 9-inch spherical shell of that day. Unfortunately, the commendable work done by Mr. Stevens, and embodied in his famous floating battery, was not immediately followed up, and we must turn to France for the successful beginnings of the armor-plate industry. In 1854 the French engineer Dupuy de Lome designed the armored frigates "Gloire" and "Heroine," and their iron plates, 4¾ inches thickness, were shortly afterward rolled at the works of Messrs. Schneider & Company, a firm which has been closely identified with the development of armor-plate ever since the inception of the industry. The civil war in this country led to the construction of the monitors,

All-steel. Nickel-steel. Compound.

RESULTS OF THE ANNAPOLIS ARMOR-PLATE TESTS.

and the development of armor-plate was carried on with such activity that by the close of the war there were vessels in the United States navy which carried armor as thick as 11 and 15 inches in their turrets.

The armor of that day was built up of half-inch plates riveted strongly together. It was effective against round shot, but was easily penetrated by the rifled projectiles that were subsequently introduced. The solid wrought iron armor, which took the place of the laminated armor, was, of course, of superior resisting quality; but it fell an easy prey to the Palliser chilled shot, a cast iron projectile with a chilled head of great hardness and resisting quality.

When the complete superiority of the Palliser shot was evident, armor-plate makers began to cast about for some method by which the hard point of the projectile might be broken. Two ways of effecting this presented themselves. The first was to give up wrought iron altogether and adopt the harder material steel; the other was to retain wrought iron for the body of the plate and devise some way of hardening its front surface. The object at which all armor-plate makers were aiming was to produce a plate which would be extremely hard, sufficiently so to break up the projectile, and yet so tough that, if the projectile should hold together and penetrate, it would merely punch a clean hole, without cracking the plate entirely through and knocking it piecemeal from its backing.

Compound Armor.

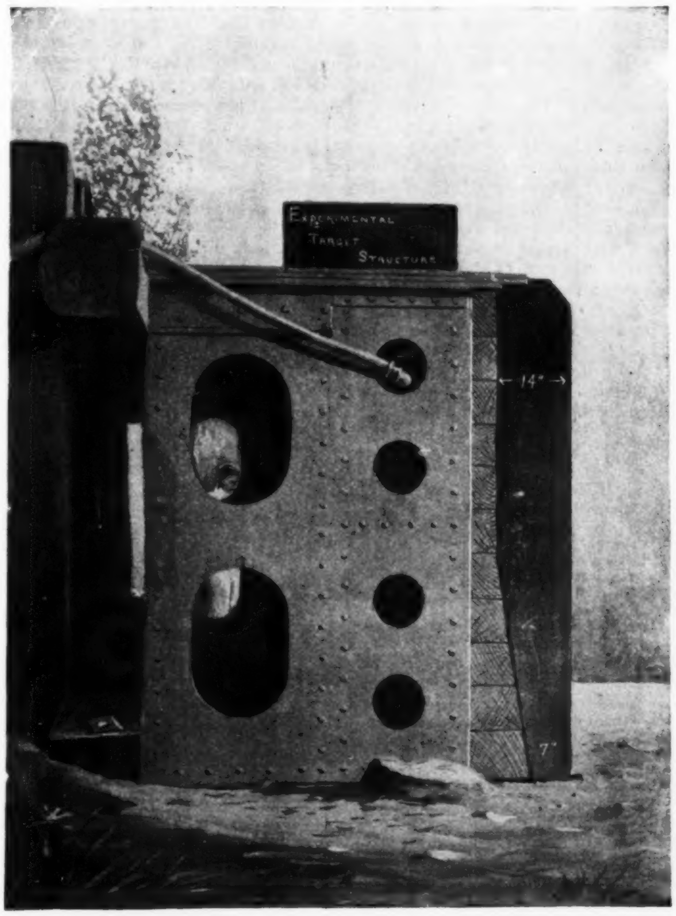
The English adopted what is known as "compound armor," which consists of a soft iron back upon which is welded a hard steel face. Two methods of manufacture were employed, one by Cammell & Company and the other by Brown & Company, both of Sheffield. The Cammell plate was made as follows: A soft iron forged or rolled plate was raised to a welding heat and a layer of molten steel run onto its front face. After the plate had partly cooled it was rolled, and the steel face further treated to improve its quality. The Brown method consisted in placing the steel face and wrought iron back in a furnace, the one above the other, and as soon as they were raised to a welding heat, running in molten steel between them.

Steel Armor.

The first steel armor proved to be too brittle; it cracked badly and broke into fragments. When its hardness was reduced, however, it failed to keep out the projectiles, although, taken altogether, it was superior to the best wrought iron of the day. An endeavor was made to secure the same results as were aimed at in the compound armor, by oil-tempering the face of the steel plate, thereby securing a hard face and tough back in a plate of homogeneous metal. The results obtained with both the steel and compound plates were for awhile very satisfactory, for the Palliser chilled shot was fractured and failed to penetrate.

It now became necessary to provide a more effective projectile, and a suitable shell was produced by alloying a small percentage of chromium with the steel. Chrome steel, which is now the material from which practically all modern shells are made, has remarkable resisting qualities, and from the very first the chrome steel shells achieved a complete victory over both the steel and compound armor.

The next investigations were in the direction of finding a substance which could be combined with the steel to increase its toughness and enable the plate to hold together, even if it should be badly penetrated. It was discovered that a certain proportion of nickel



[Represents framing behind the belt armor of the "Iowa," with ballistic test plate B-230, group No. 21. "Iowa's" 14-inch Harveyized nickel-steel side armor plate mounted thereon.]

BATTLESHIP "IOWA"–EXPERIMENTAL TARGET STRUCTURE FOR TESTING BELT ARMOR.

gave the desired qualities, and the nickel-steel plate was quickly recognized as the best type of armor yet produced.

We present an illustration of the notable test which was carried out by the United States government at Annapolis in 1890, to determine the relative qualities of the three types of plate—all-steel, nickel-steel and compound. The all-steel plate manufactured by Messrs. Schneider & Company, at the Creusot Works, was $10\frac{1}{2}$ inches thick; the nickel-steel plate, also from the Creusot Works, was $10\frac{1}{2}$ inches in thickness; the Cammell plate 11 inches. The plates were arranged tangentially to an arc of a circle whose center was occupied by the pivot of the gun. Two guns were used in the trial, a 6-inch and an 8-inch, the former firing four shots at each plate and the 8-inch gun, one shot.

The trial commenced with the firing of four 100 pound Holtzer shells, with a velocity of 2,074 feet per second, at each plate, one shell being delivered toward each corner of the plate, as shown in the illustration. The 6-inch gun was then replaced by an 8-inch gun, and each plate received a final blow directly in the center from an 8-inch projectile.

The results were as follows: The four 6-inch projectiles in every case pierced the Cammell plate cracking and breaking up the hard steel face. The all-steel plate fared better, none of the shells making a complete perforation, one of them remaining embedded in the plate and the others rebounding from the plate or being broken up by the impact. The nickel-steel plate showed the best results. The first shell barely pierced the plate and was broken into fragments. The second and third shells were embedded in the plate. The point of the fourth shell barely got through, but the projectile was completely broken up. A few days later the final test was made by firing an 8-inch 210 pound Firth shell at the center of each target. The effect on the compound plate was to completely demoralize it, the whole of the steel face being brought away from the plate; the shell passed through both plate and backing. It is only fair to add that the soft iron back fulfilled its purpose in holding what was left of the plate together.

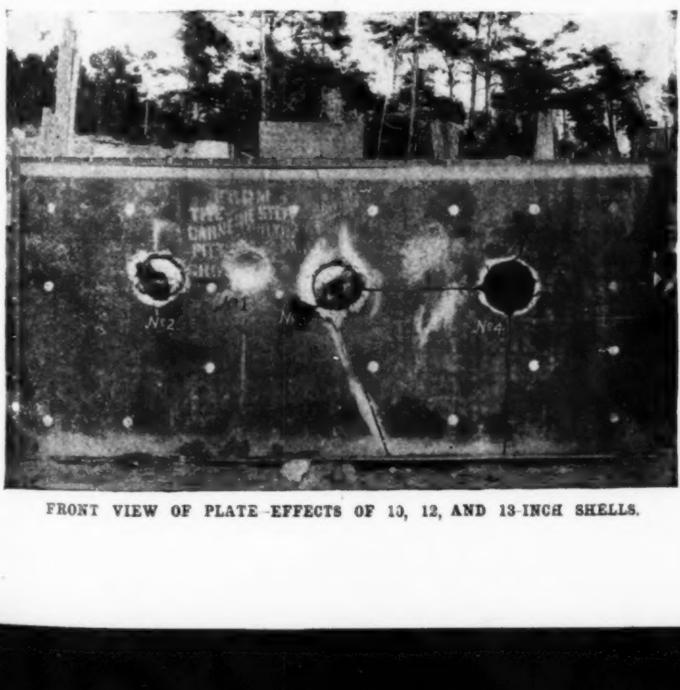
The all-steel plate was penetrated, although the shell rebounded and was broken up; but it was badly cracked, the fracture running from the 8-inch hole diagonally to the edges of the plate. The nickel-steel plate again showed its superiority, for not only did the shell fail to get through, its point remaining embedded, but the plate itself was absolutely free from cracks, thus demonstrating its ability to hold together under the terrific attack to which it was subjected.

The result of this famous trial was the immediate adoption of nickel-steel by the United States government as the material for all armor plate.

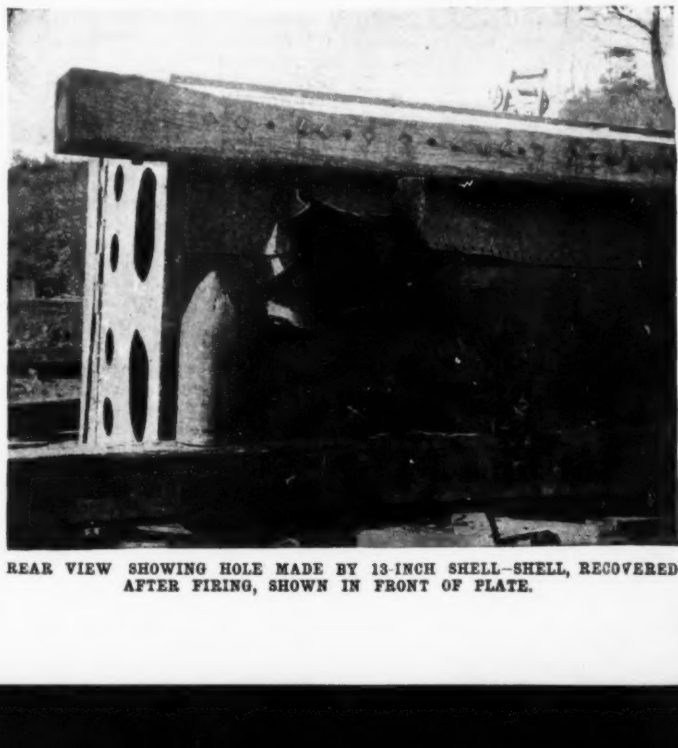
It will be observed that while the hardness and toughness of nickel-steel limited the penetration and prevented the fracture of the plate, it failed to keep out the shells entirely. What was now needed was the combination of a tough and hard interior body with an intensely hard face. This was secured by treating the nickel-steel plates by the Harvey process of face hardening.

The Harvey process achieved the same victory over the chrome-steel shells that the compound plate obtained over the chilled Palliser shells—breaking up the point of the shell at the moment of impact. It is an American invention, and takes rank with the Creusot nickel-steel as one of the greatest improvements ever introduced into the art. The process consists of placing the plate in a furnace with only its face exposed. Carbonaceous material is then spread over the furnace, completely covering the face of the plate. After it has been subjected for a considerable length of time to a high temperature, the plate is allowed to partly cool, after which the face is uncovered and given an intense hardness by the application of cold water.

A further improvement on the Harvey process con-



FRONT VIEW OF PLATE–EFFECTS OF 10, 12, AND 13-INCH SHELLS.



REAR VIEW SHOWING HOLE MADE BY 13-INCH SHELL–SHELL, RECOVERED AFTER FIRING, SHOWN IN FRONT OF PLATE.

sists in reforging the plate after it has been face-hardened, by heating it and subjecting it to hydraulic pressure. The density and toughness of the plate are greatly increased, and these qualities, combined with the intensely hard face, produce a plate whose resisting qualities, in proportion to its weight, are greatly augmented as compared with the early Harveyized plates.

Test of Belt Armor of Battleship "Iowa."

The question has been asked whether, even supposing the plate should keep out projectiles, the framing of the ship would prove equal to holding up the plate. We present three views of the test of a full sized target, representing the side armor, backing and frame of the battleship "Iowa." Four shots were fired at the 14-inch nickel-steel plate, with the results shown in the illustrations. Shot No. 1, from a 10-inch gun, penetrated 3¾ inches and was shattered. No. 2, also a 10-inch shell, struck with a velocity of 1,856 feet a second and energy of 11,954 foot-tons, and penetrated 11 inches, the head being welded in. No cracks developed in the plate. The third shell, fired from a 12-inch gun, struck with an energy of 19,114 foot tons. The shell penetrated 17 inches and broke up, the plate being cracked through from top to bottom. Shot No. 4 was from a 13-inch gun. Its striking energy was 24,736 foot-tons. It passed through the entire target and was found buried 12 feet in the sand at the rear. The shell (shown in the third cut) was shortened 3 inches by compression and increased ½ inch in diameter near the head. As the plate stood the test of the two 10-inch shells without cracking or complete perforation, the lot which it represented were accepted.

The structural efficiency of the framework of the ship was fully demonstrated by its good condition at the close of the trial.

Test of the Turret of the Battleship "Massachusetts."

Another test of a full sized target, similar to the foregoing, was carried out in the fall of 1896 to determine the structural strength of the turrets which carry our 13-inch guns. It was considered advisable to learn what the secondary effects would be if a turret were struck squarely at close quarters by one of the largest modern projectiles. The turret might be distorted, or it was possible that it might be moved bodily upon its supports, in which case the elaborate gear, hydraulic or otherwise, for turning the turret and working the guns would be disabled.

The turret was built up as an exact duplicate of the 13-inch turrets of the "Massachusetts," except that only one steel plate (inserted to test its quality) was used, cast iron plates of equal weight being substituted for the others. Dead weight was placed within the structure to represent the guns, mounts and machinery, and it was mounted upon rollers laid on a circular path of wrought iron plates.

The experimental steel plate was one which had already been used in experimental tests, and had successfully resisted two heavy armor-piercing shells, the points of which were embedded within it. In the present experiment three rounds were fired, as per the accompanying table:

	Round 1.	Round 2.	Round 3.
Gun..........	10-inch.	12-inch.	12-inch.
Projectile.....	500 pounds.	850 pounds.	851 pounds.
Velocity ...	1,863 foot secs.	1,701 foot-secs.	2,000 foot secs.
Energy......	9,829 foot-tons.	17,069 foot-tons.	23,626 foot-tons.

The first shell, a 10-inch Wheeler-Sterling, broke upon the plate with a penetration of 9½ inches. The point of impact was 14½ inches from the top of the plate and 2 feet to the left of the second of the points of impact above mentioned. The whole turret was moved backward on its rollers for a distance of 1¾ inches.

The second shell struck the turret at an angle of 7½° from the normal. This projectile penetrated 11½ inches and broke up. One armor bolt was broken and driven into the turret. The adjoining cast iron plate to the right was slightly displaced. The horizontal channel irons of the framework were buckled to the extent of one inch. The splinter bulkhead to the left was buckled to the extent of 3 inches. The turret itself was carried to the rear a distance of 7¼ inches, and was also turned about its axis slightly. There was no distortion of the structure considered as a whole.

The third shot was a Johnson fluid-compressed steel armor-piercing shot, 12 inches in diameter. It carried a soft steel cap and weighed 851 pounds. It struck the plate at an angle of 21° from the normal, at a point about 3 feet from the left edge and 3 feet from the top of the plate. It will be noticed that the angle of impact was very large, and when the shot struck the plate, instead of following the line of fire, it turned sharply to the right and passed entirely through the plate on a line nearly normal to its surface.

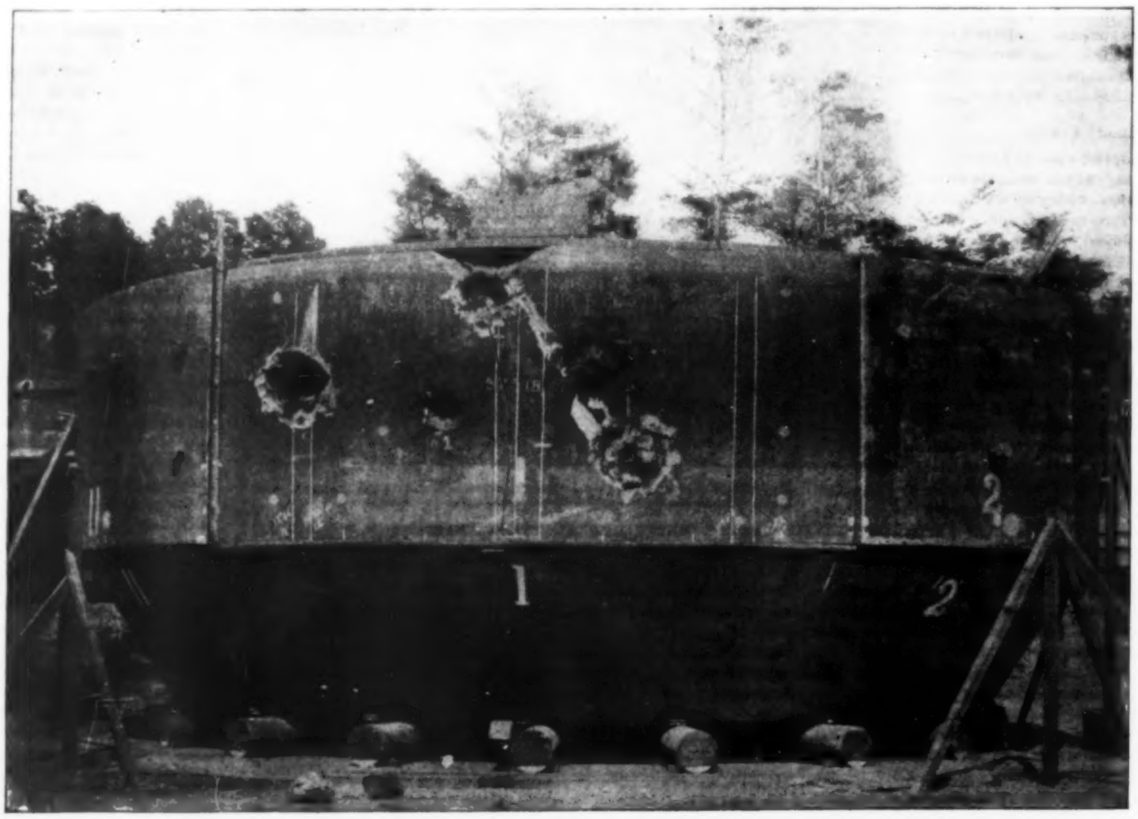
The shot broke up in forcing its way through, the larger pieces going through the covering plate on the rear side of the turret, piercing the backing, smashing off a large portion of the rear cast iron plate, and finally going into the woods behind the target.

The destructive effect of the shot is shown very graphically in the accompanying illustrations. The interior vertical covering plates on the opposite side of the turret were pierced with eighteen holes and showed numerous deep gouges and scars caused by the flying fragments. The turret structure over an area of 4 square feet where the shot struck was badly wrecked.

This impact moved the turret 9 inches to the rear, in a direction making an angle of nearly 8° with the line of the movement in the two previous impacts. It also revolved around its center to the left through an angle of 2°. The result of the test proves that the framing of the turret has ample strength to resist the heaviest strains that could come upon it under fire. The fact that the turret as a whole moved as much as 9 inches under the energy of the shot raises the question of the sufficiency of the means adopted to hold the turrets of our battleships in place. As at present constructed, the tendency to translation of the turret is resisted by the flanges of the steel rollers upon which it revolves, and it was estimated at the time by Admiral W. T. Sampson that these flanges present an ample margin of strength to resist the shearing action to which they are subjected.

Referring again to the photograph showing the destruction wrought in the interior of the turret by the flying fragments of the successful shot, it is evident that, had the turret been occupied by actual guns and gun crew, the gun itself and the larger part of the crew would have been disabled. It is also noteworthy that successful penetration was effected in spite of the fact that the shot struck at a high angle of incidence, and there is no doubt but what it was largely due to the action of the soft steel cap, as explained elsewhere in this issue.

In concluding this chapter on armor-plate we draw attention to the fact that nowhere in the great industrial field which is devoted to the manufacture of war material has this country achieved a more brilliant success than in the construction of armor-plate. The Annapolis tests fairly revolutionized the art, and the pre-eminence achieved at that time has never been lost. Too great praise cannot be given to Harvey, Corey, the naval and army experts, and our great armor-producing firms, such as the Carnegie and Bethlehem Companies, for the uniformly excellent results which continue to attend the trials of American armor.



EXPERIMENTAL TURRET OF THE BATTLESHIP "MASSACHUSETTS" EXTERNAL VIEW, SHOWING COMPLETE PENETRATION OF 15-INCH, HARVEYIZED, NICKEL-STEEL PLATE.

SMOKELESS POWDER.

GUNPOWDER, in the shape of the common powder with which we are all familiar, is a more or less perfect mechanical mixture of three substances—nitre, charcoal and sulphur. The proportions vary slightly in different powders; but usually they are 75 parts nitre, 15 parts carbon and 10 parts sulphur. When these materials are ground and thoroughly mixed, so that the different molecules are brought into close association with each other and are ready for instant combination, the result is an explosive which only needs the presence of heat for its action.

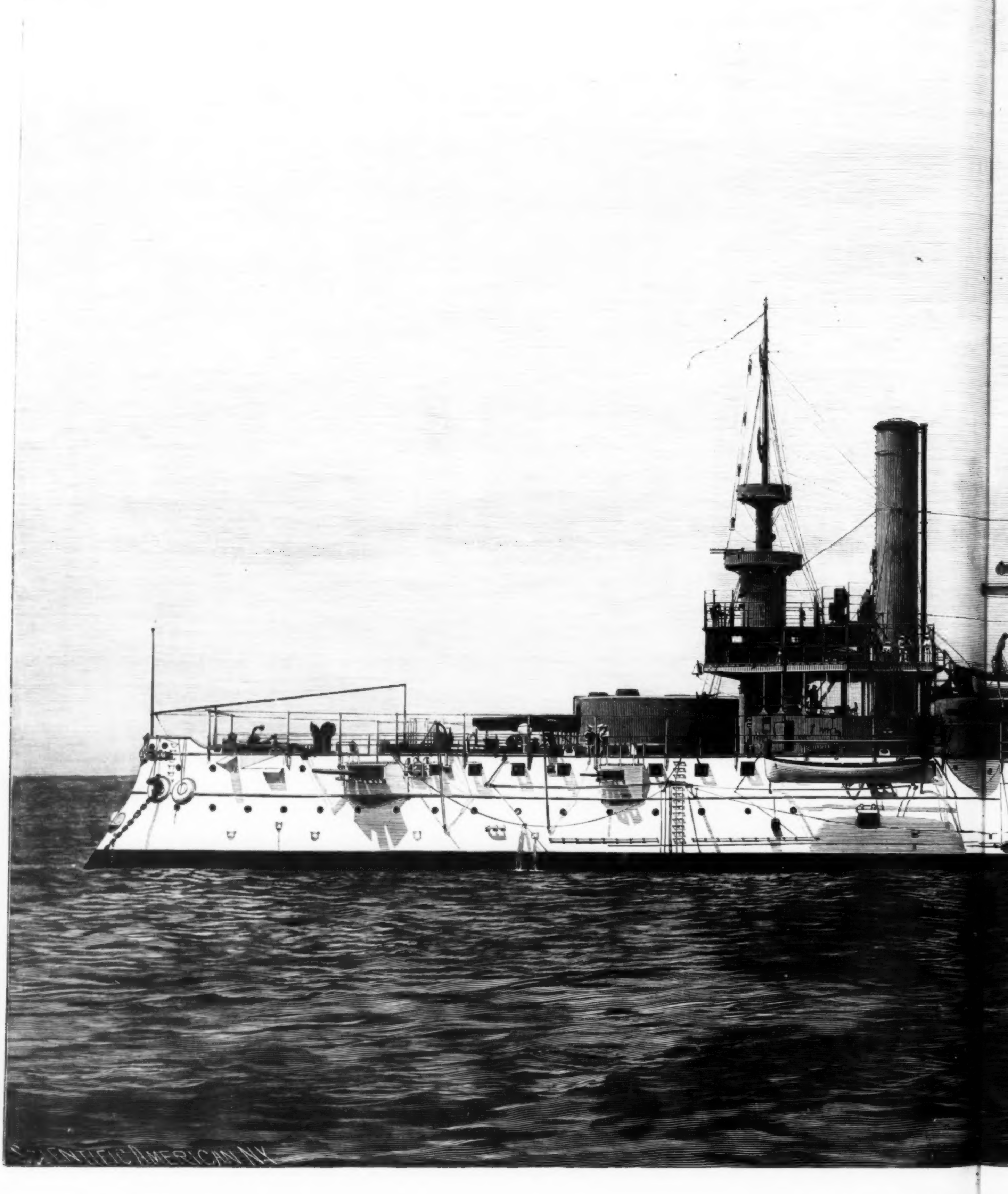
Previous to, and at the time of the civil war, gunpowder was pretty much the same in its appearance and action as it had been through all the centuries which had intervened since its discovery. The only important change was to form the powder (as first used it was a dust) into grains; but the grains were very fine, and the combustion was sudden, giving inconveniently high pressures in the gun.

When a charge of common black powder is ignited, the whole of it is instantly converted into gas, producing an extremely high pressure at the breech of the gun. As the shot moves through the bore, the pressure falls rapidly, owing to the increased volume of the gas, the pressure just as the shot leaves the muzzle being quite insignificant. This was proved in an experiment made some years ago, in which the actual powder pressures were taken by gauge at each foot of the bore during the firing of a 38-ton muzzle-loading gun. The pressures were as follows:

	Breech.															Muzzle.
Distance in feet traveled by shot.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Tons pressure per square inch...	23·8	22·5	10·9	14·2	11·6	7·0	8·8	2·9	...	.	...	1·9	1·6	1·3	1·1	0·6

It will be seen that the first four or five feet of the gun are subjected to excessive pressures, whereas the pressures on the last six or eight feet were exceedingly light. It is this unevenness of pressure that explains the bulky appearance of the early guns at the breech, and their short length, as compared with our modern rifles. There was no object in prolonging the bore of a gun beyond a point where the effective pressure had fallen to $\frac{6}{10}$ of a ton to the square inch.

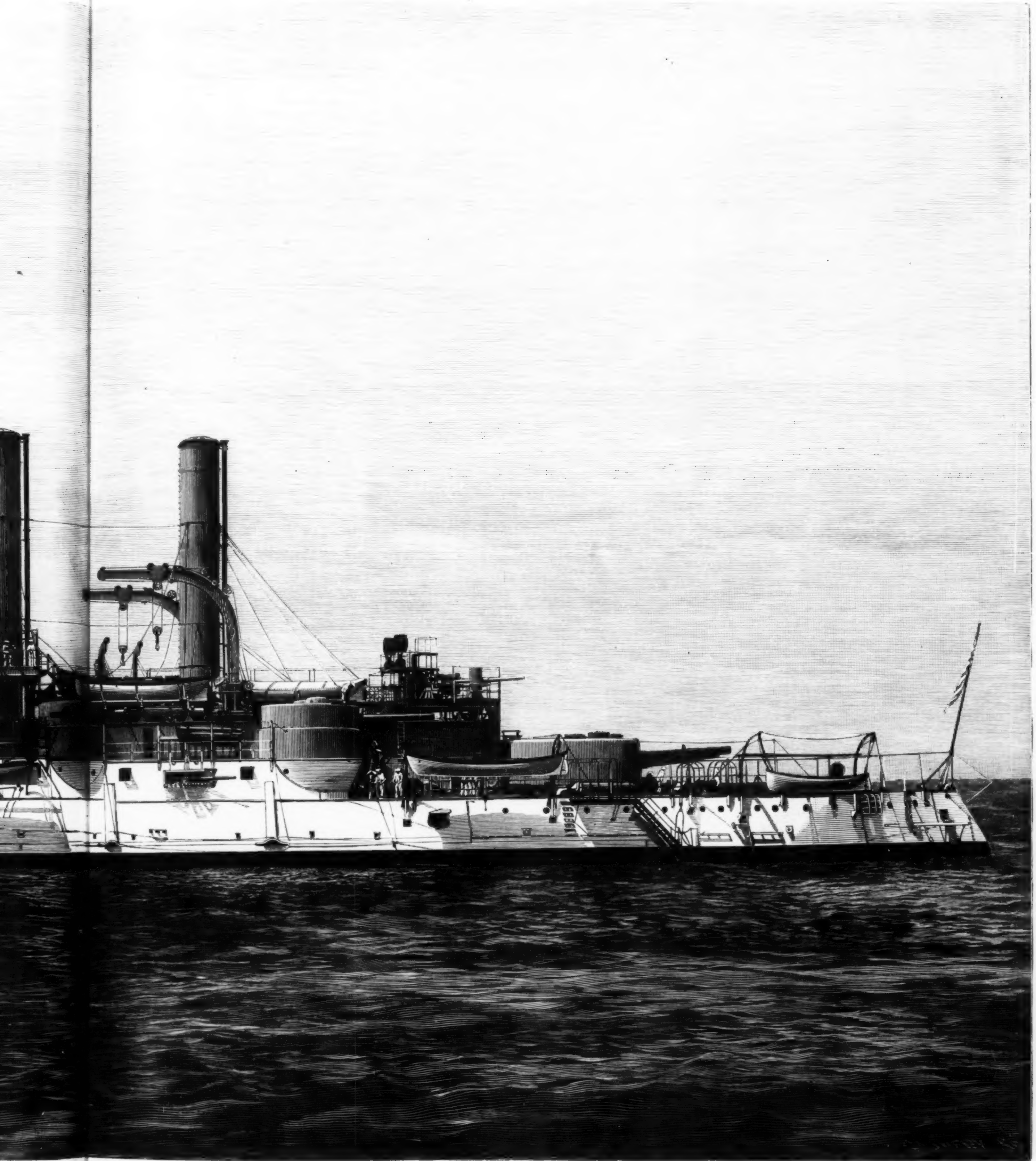
It is evident on looking at the above table that if the pressure were more evenly distributed along the bore, the same velocity might be obtained with a gun of



U. S. BATTLESHI

Displacement, 11,340 tons. **Speed,** 17·1 knots. **Maximum Coal Supply,** 1,795 tons. **Complement,** 5
Guns . Main battery, four 12-in., eight 8-in., six 4-in. rapid-fire ; secondary rapid-fire battery, twe -poun

ARMY AND COAST DEFENCE EDITION
OF THE
SCIENTIFIC AMERICAN SUPPLEMENT No. 1175.



BATTLESHIP "IOWA."

5 tons. **Complement**, 505. **Armor**: Belt, 14 in.; deck, $2\frac{3}{4}$ in.; barbettes, 15 in.; turrets, 15 in.; casemates, 5 in.
re battery, twenty 6-pounders, four 1-pounders, four Colts, two field guns. **Torpedo tubes**, four. **Authorized** 1892.

much lighter or more uniform construction. If, for instance, the powder could be converted into gas behind the shot gradually, the last of the powder being burned as the shot reached the last foot or two of the gun at the muzzle, it would be possible to produce a full "indicator card," if we may use the term, and maintain a moderate and uniform pressure throughout the bore.

The credit for solving this problem is due to Major Rodman, of the United States army, who found that the rate of combustion could be controlled by varying the size of the grains and increasing their density. He used large grains for large calibers and varied the size with the guns. In the form of dust, the old powder burns with great violence, but in the form of cubes, spheres, hexagons, etc., it burns progressively. The explanation lies in the fact that combustion takes place on the exterior surface of the grains. The total surface of a given bulk of powder will vary with the fineness of the granulations—being less, the larger the grains.

The improvements introduced by Rodman enabled him to build successful cast iron guns of the extreme caliber of 20 inches. The ideas which he introduced have exerted a powerful influence upon the art, and to this talented officer is due much of the credit for the efficiency of modern powders and modern breech-loading rifles.

The powder at present in use (though shortly to be superseded) in our larger guns is known as brown prismatic, so called from its color and form. It is a dull chocolate in color, and, as will be seen from the accompanying illustration, it is made up into hexagonal prisms, which are about 1 inch high and 1·4 inches between faces. Each prism is perforated with an axial hole. Although the main ingredients are the same, the proportions have changed from those of the black powder. It contains 81·5 per cent of nitre, 15·5 per cent of charcoal and 3 per cent of sulphur. The field and siege guns use a smaller grained powder, the grains being of a spherical shape, with a hexagonal band formed around them. The hexagonal powder, with grains whose shape is that of two hexagonal pyramids joined base to base, is used in the 8-inch converted rifle of the kind shown on the fourth page of this issue.

Although the modifications above mentioned greatly improved the action of the powder, they introduced certain disadvantages. The charge was relatively larger, occupying a greater length of the bore and reducing the travel of the projectile. This necessitated a longer gun, and hence the cost both of gun and powder was considerably increased. Moreover, the new powder produced excessive volumes of smoke.

In the search for some more suitable powder, it was inevitable that the high explosives should attract the attention of artillerists, and among these the best known and apparently the most available was guncotton.

INTERNAL VIEW, SHOWING PENETRATION AND DESTRUCTION OF REAR WALL OF TURRET BY FLYING FRAGMENTS OF THE SHOT AND ARMOR.

Manufacture of Guncotton.

For the manufacture of guncotton in the factory established at the naval torpedo station and war college (Fort Wolcott) in 1883, the cotton used is cop or weavers' waste, which is received in bales of about 500 pounds each (Fig. 2). The bales are opened, and the cotton is picked over and placed in the cotton boiling tubs, about 200 pounds in each tub (Fig. 3), to which is added about 250 gallons of water and 35 pounds caustic soda. The cotton is boiled in this solution for eight hours, then drained overnight; it is then boiled for eight hours in clear water, again drained, and then thoroughly washed in a centrifugal wringer or extractor. It is thus freed from oil and other impurities.

It is then spread on the wire netting shelves of a suitably arranged dry room, through which hot air, at about 180° F., is circulated, and is sufficiently dried to be picked.

The cotton as received in the bales is full of knots and rolls, and the boiling adds to them. To prepare it for conversion into guncotton, it is necessary to take them out, that the acid may penetrate easily and quickly through all parts of it. To accomplish this result, the cotton is passed through a picker—a machine common to all cotton factories (Fig. 5).

Having been opened out by the picker, it is dried as thoroughly as possible. This is done by placing it in the wire-netting-bottomed drawers of a specially constructed drier.

When dry the cotton is stowed away in powder tanks (Fig. 7), so that it may be conveniently handled, and also kept dry. It is now ready for the conversion process.

This is carried on in the dipping room, which is fitted with cast iron dipping troughs, located in a tank of running water, proper cooling troughs, and acid reservoirs. The acid used is received already mixed, contained in iron drums of about 1,200 pounds capacity. The mixture is, as nearly as possible, one part by weight of pure nitric acid of 1·5 specific gravity to three parts by weight of pure sulphuric acid of 1·85 specific gravity, and costs 3¼ cents a pound. As in the converting and the two succeeding steps of the purification process a great deal of acid fumes is liberated, the dipping and two following pieces of apparatus are connected with a fan, to take it up and drive it out. The prepared cotton is brought to the dipping room on the railway running through the factory. The dipper fills the troughs with acid and arranges his tools for use. The helper weighs out a pound of dry cotton, with which he approaches the dipper, and, pitching about a third of it into the acid (Fig. 8), the latter submerges it with a steel fork, made for the purpose, and so on, until the first trough is charged with the pound of cotton. The other three troughs are similarly charged. When about ten minutes have elapsed, the dipper returns to the first trough, and with the fork gathers the guncotton out of the acid and puts it on a grating at its further end, and there squeezes the surplus acid out with a hand press (Figs. 9 and 10). By the time this is done, the helper has placed a stone jar, into which the two place the guncotton from the first trough. The helper presses it down in the jar, puts a cover over it, and sets it in a cooling trough. The dipper replenishes the acid, and the trough is charged with cotton as before, and so on, until the day's dipping, about 110 pounds, is finished. The jars are left in the cooling troughs overnight, so that their contents may thoroughly digest, and there remain no unconverted particles of cotton (Fig. 12).

From the cooling troughs, the guncotton is taken to a centrifugal wringer, two jars at a time, in which the acid is extracted and caught in a drum (Fig. 13).

The guncotton, having been approximately freed from acid, is taken to the immersing tub, in which washing out the free acid is begun (Fig. 14).

The guncotton is taken out of the immersing tub, and thoroughly washed in a centrifugal wringer, and then placed in a guncotton boiling tub, where it is boiled in fresh water, and 10 pounds of carbonate of soda, for eight hours. It is then drained, and thoroughly washed in a centrifugal wringer, and boiled again for eight hours, in fresh water, and again drained and washed as before.

After the second boiling and washing, it is taken to the pulping machine (Fig. 15), which is similar to the machine used in paper mills for pulping paper stock. In this machine, which is suitably filled with water, it circulates between the knives until pulped to about the fineness of corn meal.

From the pulping machine it is drawn off into a poacher, which is a large oval tub provided with a paddle-wheel in the middle of one side, working just clear of a platform with inclined approaches (Fig. 16). The pulp and a sufficient quantity of water being in the poacher, its paddle-wheel is made to revolve, which causes both pulp and water to circulate, and the latter to wash the former. After an hour's washing the paddle-wheel is stopped, upon which the guncotton settles to the bottom. The soiled wash water is drawn off by means of a telescopic pipe at one end of the poacher. Fresh water is added, and the cleansing continued until the washing water ceases to become soiled. The guncotton is then supposed to be clean and without free acid.

A sample is taken from the bottom of the poacher and submitted to the solubility test, to determine what percentage of soluble guncotton it contains, which must be less than ten per cent. The lower orders of guncotton are soluble in a solution of one part alcohol and two parts ether, and by means of this solution the test is made. It is then submitted to the heat test, to determine whether any free acid remains. To make this test, small quantities of the sample, thoroughly dried, are placed in test tubes which are filled in a hot water bath, carrying a suitable thermometer. The mouths of the test tubes are closed with corks, under which are suspended pieces of iodide starch paper, which has been very carefully prepared. The bath is heated to 150° Fah., and the guncotton must bear this temperature for not less than fifteen minutes without turning the test paper brown.

Having passed the tests, the next step is to prepare it for service use. To every poacher full of it there is added 3 pounds precipitated chalk, 3 pounds caustic soda, and 300 gallons of lime water. So fortified with alkali, it is pumped into what is called the stuff chest, a round tank with a vertical shaft, carrying feathers to keep the pulp agitated and mixed with the water (Fig. 17).

The guncotton being in the stuff chest is drawn thence and moulded, or pressed into shape for compressing, which is accomplished by means of a hydraulic press arranged for the purpose. Knowing the size of the compressed block desired, it is determined by experiment how much of the pulp is necessary to produce it, increasing or decreasing the length of stroke of the press pistons, then the moulding is proceeded with. The standard guncotton block for naval use is 2·9 inches square and 2 inches high (Figs. 20 and 21), to produce which the moulded block must be 2·8 inches square and 5½ inches high (Fig. 19), moulding at a pressure of 100 pounds to the square inch.

From the moulding press the blocks are taken to the final press, which is one of Sellers hydraulic presses with an 18-inch ram (Fig. 18). In the receiver of this press the moulded blocks are placed between two perforated steel plates, a traveling block is then hauled over and the pump started, which forces up the ram and the pistons on top of it, which acts on the guncotton in the receiver. The naval service guncotton is compressed at three tons to the square inch, and leaves the press with from 12 to 16 per cent of moisture, which is increased to about 35 per cent before issue to the service. It goes into the service packed in the standard tin exercise torpedoes and tinned sheet iron service torpedoes, which are capable of being made water and air tight, and have the necessary fitments for filling, fusing, and being attached to spars preparatory to explosion (Figs. 22 and 23).

Manufacture of Smokeless Powder.

The early attempts to substitute guncotton for common powder failed because of the tendency of the guncotton to detonate, instead of burning with that slow combustion which, as we have seen, is necessary to give the best ballistic results in the gun. Having in view the excellent slow-burning results obtained by varying the form and density of common powder, the same principle was applied to the preparation of the guncotton. It was formed into strands, or mixed with untreated cotton, or compressed into blocks; but as no attempt was made to essentially modify its physical condition, the fibrous texture of the guncotton allowed the flame to pass throughout the whole mass, instantly converting it into gas, with destructive effects on the gun.

About the year 1884 it was discovered that nitrocellulose or guncotton has a valuable property which does not characterize the pure cotton; namely, that it is capable of being dissolved by various substances, such as acetone (a fluid somewhat resembling alcohol) or a mixture of alcohol and ether. If guncotton is dissolved in acetone and the solution evaporated, there is obtained a solid, somewhat translucent substance, in which the fibrous form of the original guncotton has disappeared. It burns at a regular rate on its exterior surface, and it is dense enough to resist penetration by the flame.

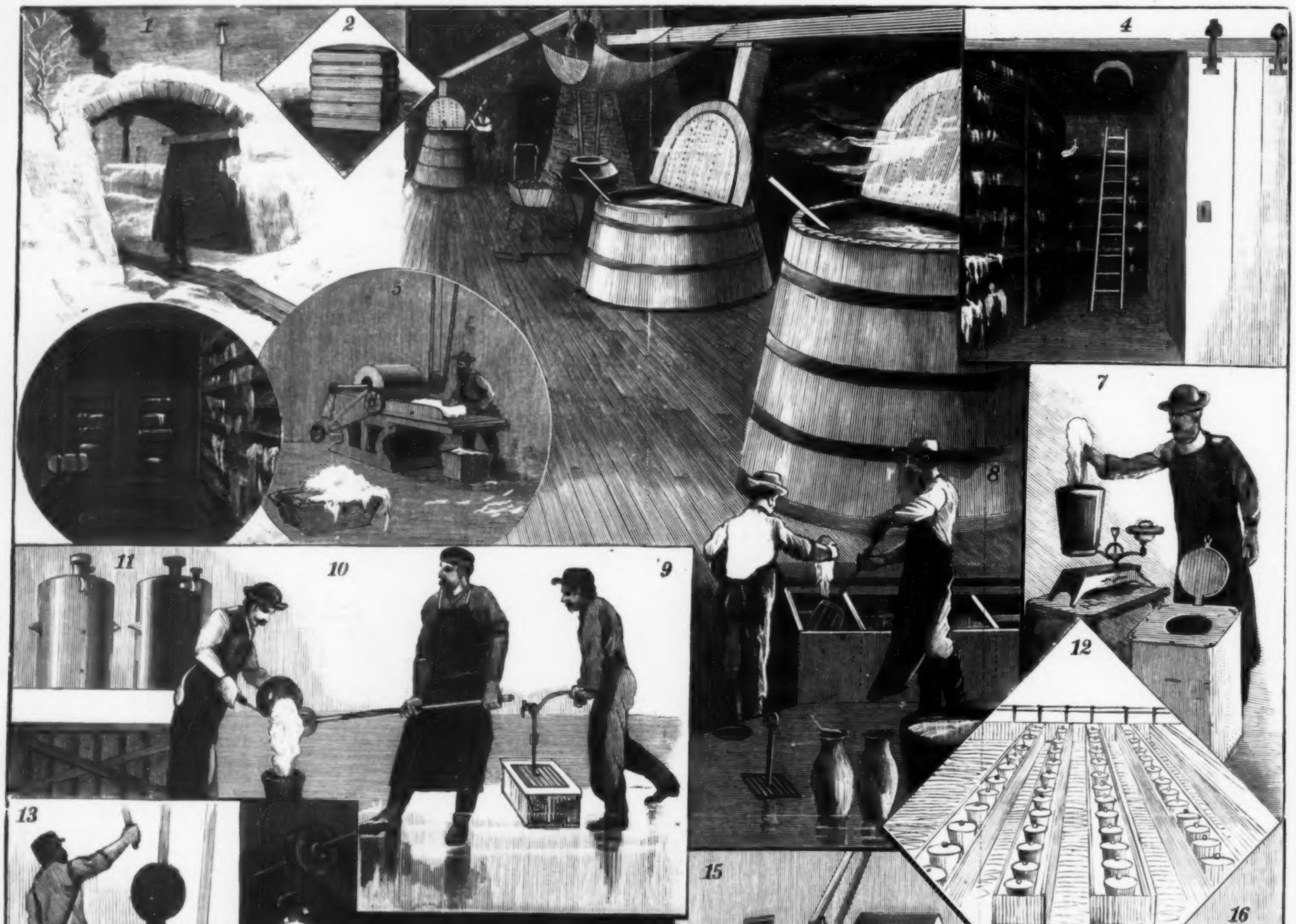
Smokeless powders may be broadly distinguished, as far as their composition is known to the public, into

those which are prepared entirely from guncotton and those which are made from guncotton and nitro-glycerine. The United States navy prefers the smokeless powders of the nitro-cellulose type. Those in use by the army contain about 25 per cent of nitro-glycerine.

In the manufacture of nitro-cellulose smokeless powder, the guncotton is first dissolved by pouring a suitable solvent over it, great care being taken that no undissolved fibrous lumps remain. The solvent is evaporated by passing a current of warm air over the guncotton as soon as it has reached a gelatinized condition, and the vapors are condensed for further use. The residue, which is now in the form of a sheet, more or less porous, is next subjected to pressure to give it a uniform density, and squeeze out any bubbles that may have formed during evaporation. It is then rolled to a uniform thickness. The product is a horny substance, incapable of being formed into grains. The desired shape is given by cutting it into specified forms, or by squeezing it through dies when it is yet in the pasty condition.

The material is then dried slowly and at a low temperature, and the product, which is of a light straw or dull chocolate brown color, is commercial smokeless powder.

The smokeless powders produced by uniting nitro-cellulose and nitro-glycerine, such as ballistite, cordite,



1. Entrance to Fort Wolcott, location of U. S. guncotton factory. 2. Bale of cop, or weaver's waste. 3. Boiling room. 4. (1) Drying room, temperature 180° F. 5. Picking machine. 6. (2) Drying room, temperature 225° F. 7. Weighing before "dipping." 8. Dipping in mixed acid—sulphuric (3) and nitric (1). 9. Pressing out mixed acid. 10. Potting in digesting pots. 11. Earthenware acid holders, or reservoirs. 12. Digesting pots in cooling troughs. 13. Centrifugal acid extractor. 14. Immersing tub and wringer. 15. Pulping machine. 16. Poachers. 17. Stuff chest and moulding machine. 18. Hydraulic press. 19. Guncotton block moulded. 20 and 21. Guncotton block compressed for service use. 22. Exercise torpedo. 23. Service torpedo.

UNITED STATES GUNCOTTON FACTORY AT TORPEDO STATION, NEWPORT.

18896

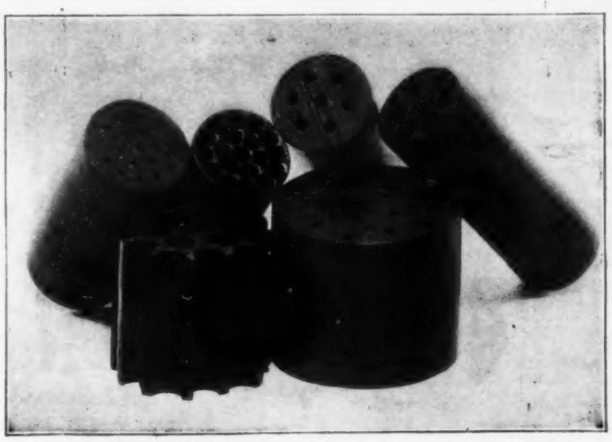
Maximite and Leonard powder are extremely powerful, but perhaps not so reliable as the all-nitro-cellulose powders. Ballistite, used in Germany and Italy, is the invention of Alfred Nobel. This was the first successful combined guncotton and nitroglycerine powder. Cordite, the English service powder, the invention of Abel and Dewar, is similar to ballistite, and both employ a very large percentage of nitro-glycerine. A "slowing agent," in the shape of 10 to 15 per cent of vaselin, is used in the manufacture of cordite. The American powder, known as the Leonard, consists of guncotton, nitroglycerine and a slowing agent. The Peyton powder consists of 38 per cent of nitro-glycerine, 40 per cent of guncotton, and various other substances.

FIRING A VOLLEY WITH COMMON POWDER.

FIRING A VOLLEY WITH SMOKELESS POWDER.

The smokeless powders, because of the small quantity of the solid products of combustion and the great volume and high temperature of the gases, enable the artillerist to obtain velocities far in excess of those obtained by the use of the old powders; and they lend themselves to the formation of powder grains which insure a very perfect control of combustion. By referring to the illustration of the Maxim-Schupphaus and the United States service powders, it will be seen that the grains are of various shapes and multi-perforated in various patterns. The object of the perforation is to regulate the burning area, so that only a desired initial pressure is obtained, and the powder is consumed with such increase of burning area as to maintain a practically equal pressure behind the projectile throughout the gun.

It is evident that solid cylinders of powder would decrease in area as they burned, and there would be a corresponding decrease in the amount of gas given off. If, however, the cylinder burns up on the interior by means of suitable perforations, the burning area and therefore the volume of gases produced will increase. This action is illustrated in the engraving, showing some unburned and partially burned grains of Maxim-Schupphaus smokeless cannon powder. The partially burned grains were picked up in front of the gun after some experiments in firing powder from a gun too small for the grain of powder employed. They illustrate very clearly the action of the combustion of this powder in the gun.



MAXIM-SCHUPPHAUS POWDER BEFORE AND AFTER FIRING.

It will be seen that two kinds of perforations are employed, those in the cylinder to the right being circular, and those of the opposite cylinder being quadrilateral in section, with two sides radial to the center of the cylinder. The latter form was adopted to secure a more even and complete combustion of the powder. That this is done is shown by comparing the bulk of the solid sections which remain in the two types of powder grain.

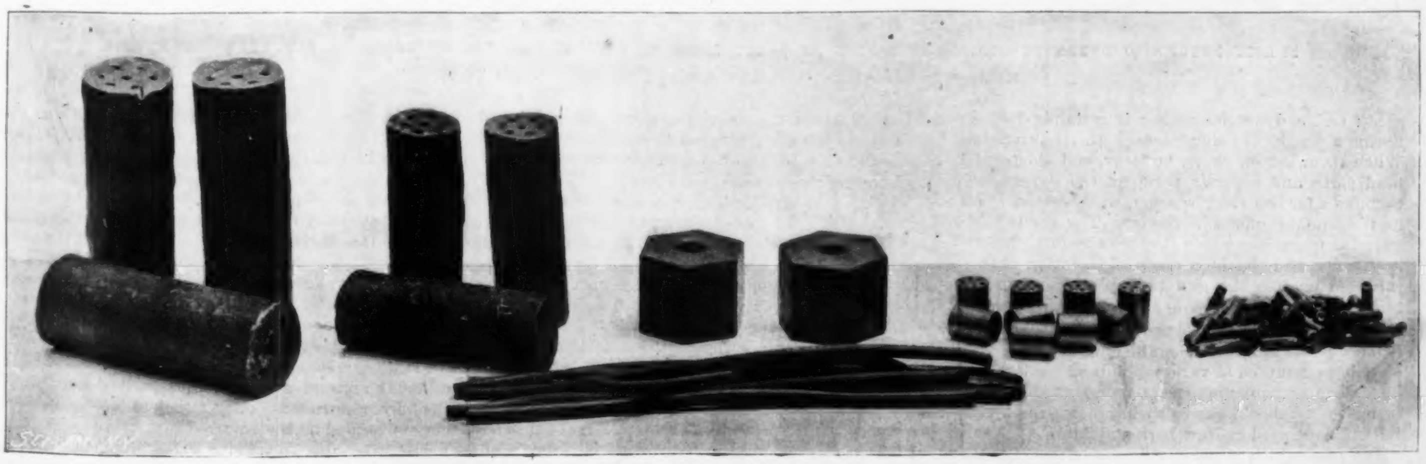
We subjoin the results of tests carried out by the United States navy at Sandy Hook and Indian Head proving grounds. With 11·75 pounds of this powder fired in a 5-inch rifle of the United States navy, a velocity of 2,556 feet per second was obtained with an initial powder pressure of 34,900 pounds per square inch. With 11 pounds of the same powder fired in a 4·7 inch breech-loading field gun, the high velocity of 2,839 feet per second was obtained with a powder pressure of 37,756 pounds per square inch. The powder consists almost wholly of guncotton and contains about 9 per cent of nitro-glycerine.

Now compare these pressures and velocities with those already referred to as obtained with the old quick-burning common powder in the 38-ton gun:

Type of gun.	Caliber.	Powder.	Max. pressure.	Muzzle velocity.
			pounds.	ft. per sec.
Muzzle-loader	12 5	Common	58,312	1,409
Breech-loader	4·7	Smokeless	37,756	2,839

The smokeless thus shows over twice the velocity for only two-thirds the initial pressure in the gun.

To these extraordinary advantages are to be added the reduction in weight and the absence of smoke. The reduced weight facilitates the operations of handling and loading. To prove the advantages of a smokeless discharge, it is sufficient to point to the operations of the present war, where our ships have been terribly hampered by their own smoke, and in many cases have had to cease firing until it cleared away. We are glad to learn, however, that a satisfactory type of smokeless powder has recently been adopted for both army and



Dupont Smokeless, for 12-inch rifles. — Dupont Smokeless, for 10-inch rifles. — Brown Prismatic (not smokeless). Cordite (smokeless) for 4·7-inch rifles. — Peyton Smokeless, for 6-pounders. — Laflin & Rand Smokeless, for 3·2-inch field-gun, siege-gun and howitzers.

PHOTOGRAPH SHOWING FORM AND RELATIVE SIZE OF ARMY SMOKELESS POWDERS.

navy, and that some of our later ships are entirely supplied with it. It is sincerely to be hoped that every effort will be made to substitute it altogether for the obsolete brown powder with which we are handicapped in the present war.

DYNAMITE GUNS.

THE recent successful attempt of the dynamite cruiser "Vesuvius" to use her pneumatic guns in actual warfare has reawakened the profound interest which was excited when Zalinski first introduced these weapons to public notice. The "Vesuvius" has proved that she can throw 500 pounds of high explosive into an enemy's fortifications, and, judging from the reports which have so far reached this country, the charges proved exceedingly destructive. The prejudice which has existed against the dynamite gun when mounted on a warship is based on the great risk to which the vessel is exposed by the dynamite being exploded by the enemy's shells. The risk is undoubtedly great, and a dynamite cruiser is certainly in danger during a conflict of being "hoist with its own petard." When mounted on shore, however, and sheltered behind earth and concrete parapets, the dynamite gun becomes a far less risky weapon, while retaining all of its tremendous offensive powers. The shells can be stored in magazines where they are absolutely safe from hostile fire, and the high angle of elevation at which it is fired enables the gun to be placed well down behind the shelter of the parapet.

One of the important elements in our system of coast defence is the Zalinski dynamite gun, of which several have been mounted at various points on our long coast-line. The accompanying cuts represent the great 15-inch, 40-ton Zalinski gun with improvements by Capt. Rapieff, as erected at New York and San Francisco.

The gun, which is necessarily smoothbore, is made of cast iron in several sections, which are bolted together, forming a tube having a length of fifty feet and an internal diameter of fifteen inches. The joints are all provided with a very efficient system of packing, which automatically tightens with the increase of pressure. The trunnions, which are hollow, communicate with an annular air space surrounding the barrel between them and the breech. They turn in boxes which support the barrel and at the same time serve to convey air to the trunnions in whatever position they may take. These boxes communicate by means of a swing joint with a cross pipe connected with the firing reservoirs located on opposite sides of the gun. The trunnion joints, as well as the swing joint, are provided with packed bearing surfaces, which may be removed for inspection or repacking without disturbing other portions of the gun.

The elevation is secured by means of a bronze elevating arc attached to the under side of the gun, within the carriage, and concentric with the trunnions, which is engaged by a worm operated by an electric motor. For traversing the gun the fixed base of the carriage is provided with a circular rack engaged by a pinion, also driven by an electric motor.

Besides these means of elevating and training the gun, the shafts are prolonged through the walls of the carriage to receive cranks for maneuvering the weapon by hand power.

The gun is provided with a quick-closing breech piece, which packs itself automatically as soon as the air pressure is exerted upon it. The main firing valve is operated by air pressure controlled by an auxiliary valve, seen in the engraving at the top of the breech of the gun, and this valve in turn is controlled by another located at the trunnion and operated by the gunner, who occupies the platform at the left side of the carriage.

The air is compressed to 2,000 pounds in a separate building, at some distance from the gun, and stored in reservoirs at that pressure. From these it is led to a set of tubes located in a subway beneath the gun foundations. The pressure is maintained in these tubes at the firing pressure of 1,000 pounds to the square inch.

The projectile, which in outward appearance is similar to the projectile of the Sims-Dudley gun, shown on the opposite page, consists of a head, a central body-tube containing the charge of dynamite, and a tail which carries the vane for giving the proper rotation to the shell. Three separate fuses are used, one in the head, which acts on immersion; one in the base, which acts only on impact with a solid target; and one for exploding the charge after sinking to the bottom, in case the immersion fuse in the head should fail.

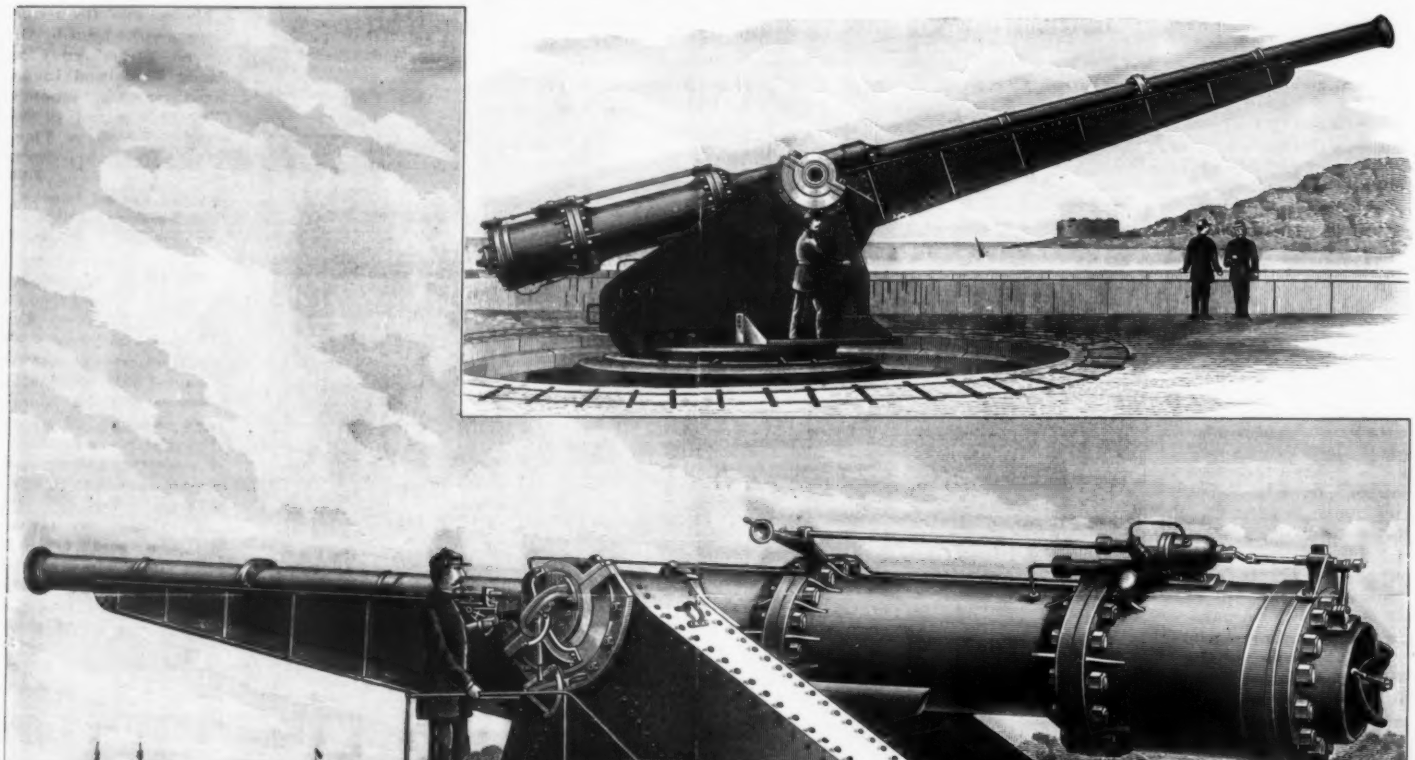
The extreme length of the gun is 50 feet and its total weight 40 tons. The total weight of the full-caliber projectile is 1,000 pounds, the explosive charge alone weighing 500 pounds. The range at 35° elevation with the large projectile is 2,400 yards; with a 10-inch subcaliber projectile weighing 500 pounds it is 4,400 yards; with an 8-inch subcaliber projectile weighing 340 pounds the range is 5,000 yards; and with a 6-inch subcaliber projectile weighing 240 pounds the range is 6,000 yards. The weight of the explosive charges in the subcaliber projectiles named would be respectively 200 pounds, 100 pounds and 50 pounds.

In the official test of the three 15-inch guns near Fort Winfield Scott, San Francisco, it was required that 34 per cent of hits should fall within a rectangle measuring 360 feet by 90 feet, at a range of 5,030 yards. In the actual test 75 per cent of the shots fell within this rectangle, and a rectangle of 210 by 156 feet would have contained them all.

This test was made with shells charged with 100 pounds of explosive, the composition of which was: nitroglycerine, 87 per cent; guncotton, 7 per cent; camphor, 4 per cent; carbonate of magnesia, 2 per cent.

In the same tests two shells of this size were fired from different guns at a hillside 3,700 yards distant across the harbor entrance. They struck 61 feet apart. The craters formed in the soft red rock by the explosions were bowl-shaped, one being 20 feet diameter by 4 feet deep and the other 30 feet diameter by 6 feet deep.

It will be interesting to learn just what effect was produced by the 500-pound shells fired by the "Vesuvius" against the Santiago forts.



15-INCH PNEUMATIC DYNAMITE GUN, AS INSTALLED AT SANDY HOOK, NEW YORK, AND THE ENTRANCE TO SAN FRANCISCO HARBOR.

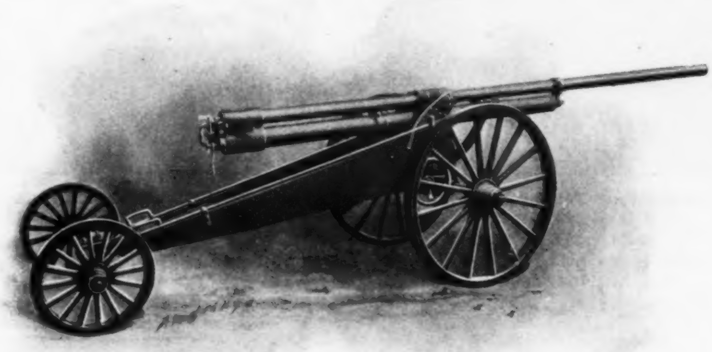
Range, with 1,000-pound shell, 2,400 yards; with 240-pound shell, 6,000 yards.

SIMS-DUDLEY PNEUMATIC GUN.

THE Sims-Dudley pneumatic gun, popularly but erroneously known as the "dynamite gun," represents another successful solution of the problem of a safe and effective method of firing high explosives. To fire high explosives in shells, it is absolutely necessary to start the shell, containing not only the high explosive but also the far more sensitive primer necessary to its explosion, without shock or rise in temperature, and also to immediately follow up the shot by the continued application of a comparatively low pressure through a sufficient distance to impart the momentum necessary to project it to the desired range. This is accomplished in the gun under consideration by compressing air in a separate cylinder below the gun by the explosion of a charge of gunpowder, and communicating the air pressure thus produced to the base of the projectile in a firing tube.

SIMS-DUDLEY PNEUMATIC GUN, LIMBERED UP.

A brief description of the gun shown is as follows, reference being made to the two cuts which show the weapon mounted on a field carriage and also in battery. The gun consists essentially of two tubes, one placed above the other. The upper tube is the longer, and is known as the projectile tube. It is of a composition metal specially manufactured for this purpose, possessing a tensile strength of about 80,000 pounds to the square inch. The diameter of the bore of this tube in the smaller gun is 2¼ inches, and its total length is a little short of 14 feet. It is smoothbore, the rotation of the shell being assured by a vane on the projectile.



SIMS-DUDLEY PNEUMATIC GUN, IN BATTERY.

Below the projectile tube is the expansion or combustion chamber, which consists of a tube of steel 4⅝ inches diameter and 7 feet long. This tube is directly connected to the projectile tube by openings at its rear end and at the top. It is also provided at its rear end with an inner firing tube which projects into the outer tube for a short distance. The projectile tube and the combustion chamber are each provided with a breech-mechanism of approved form, adapted especially for use in this gun.

In firing, the breech-mechanisms are thrown open by a single motion, the loaded projectile placed in the projectile tube, and an ordinary cartridge shell, containing 7 to 8 ounces of smokeless powder, inserted in the firing tube. The breech-mechanisms are then closed by a single movement and the gun is ready to fire. The firing is accomplished by pulling a lanyard in the usual manner. The projectile is shown in the cut. It contains an explosive charge of about four pounds of Nobel's gelatine and is provided with a Merriam fuse, which can be arranged either to explode the gelatine upon impact or any time thereafter up to six or seven seconds. The range of this particular gun is from one to two miles, depending upon the elevation, and it can be fired five or six times per minute. The guns are mounted upon an ordinary gun carriage for field use, or upon a naval mount when they are to be used afloat or on shipboard.

In actual warfare the gun has clearly shown its value in the field against infantry or cavalry, and for battering down and destroying fortifications. The earlier type of the gun has already been put to test by the Cubans, and its success in many engagements has demonstrated its eminently practical character for its designed purposes.

The projectile is 36 inches long over all and weighs, loaded, 12½ pounds. The body of the shell is a brass cylinder, having a conical head (H) containing the well known Merriam fuse. The rear of the shell carries a tail piece 10 inches long, having a vane (k) set at an angle that will insure rotation. In the main body of the projectile is placed the charge of explosive gelatine (G). In the forward end of this charge, and inclosed in a metal case, is a pencil of guncotton (J), and in the center of one end of the guncotton is a cylindrical case of fulminate of mercury. The ignition is effected by means of the mechanical fuse. When the shell strikes the water, or any other object, a steel ball, acting as a hammer, is driven forward by the sudden retardation of the flight of the shell, and strikes one or more percussion caps, causing a detonation; this ignites a tube of powder communicating with the fulminate of mercury, and so explodes successively the guncotton and the main explosive. The time of the explosion after impact may be regulated by a special adjustment of the fuse. The fuse embodies a safety device which renders the shell inactive until it has traveled at least three hundred feet in its flight from the gun.

PROJECTILE FOR SIMS-DUDLEY GUN.

When mounted it can be drawn by one horse or three or four men. It can be disconnected and placed on the back of a mule, and the carriage can be loaded on another mule. In other words, the gun and all its accessories can be carried by two mules. In the absence of mules, five men could carry the gun, and five the carriage, up any ordinary mountain side by cutting a branch about 25 feet long and using it as a carrying bar. The gun can always be assembled and ready for action in two minutes' time.

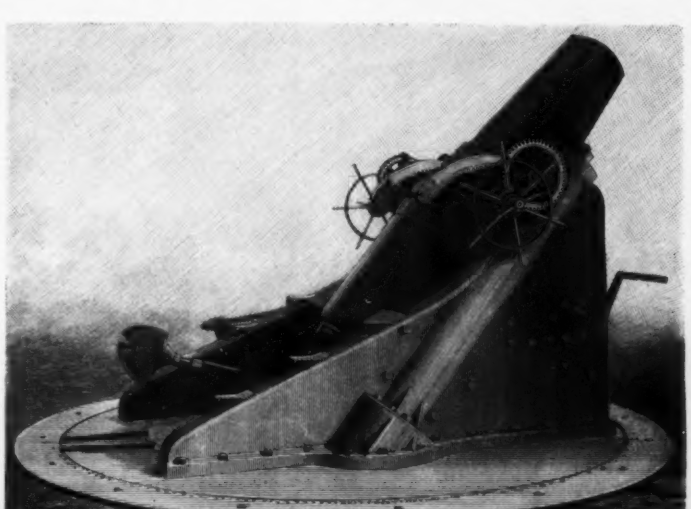
HARBOR DEFENCE.

IN the introductory chapter we pointed out that no system of coast defence is complete that does not include the co-operation of a navy, more or less efficient. The navy, however, may meet with defeat—it may be badly crippled or even wiped out of existence—in which case the country will find itself thrown entirely on the defensive, and must rely altogether upon its fortifications and submarine mines, assisted by such floating defences in the way of monitors and torpedo boats as may happen to be stationed in its various harbors.

A perfect system of harbor defence should include powerful masked batteries of long-range high-powered rifles mounted on disappearing gun carriages, and so disposed as to command all approaches and channels; numerous and carefully concealed mortar batteries so placed that a continuous rain of shells can be let fall upon a fleet in any of the navigable waterways of the harbor or its approaches; and a carefully designed system of submarine mines, the location of the mine fields being such that they can be protected against countermining operations by the fire of batteries of rapid-fire guns. The channels should be commanded by powerful search lights; and the fire of the gun and mortar batteries should be directed from concealed observing stations, in which are installed the most reliable range and position finders.

The Buffington-Crozier Disappearing Gun Carriage.

The elements of secrecy and invisibility are all-important in the location and working of harbor defences. The use of the disappearing gun-carriage and the careful "masking" of the batteries, coupled with the use of smokeless powder, make it an extremely difficult matter for an attacking ship to locate the guns which are pouring well-aimed shells upon its deck and against its sides. The disappearing gun is visible above the parapet only for a few seconds as it rises to fire, and, if smokeless powder is used, all that can be seen is a momentary black spot among the green slopes in which the battery is hidden. The United States is fortunate in possessing in the Buffington-Crozier what is probably the best disappearing carriage in the world; and as it forms one of the most important elements in our system of coast defence, we have devoted the first three illustrations of this number to the subject. The striking view on the cover, reproduced from an instantaneous photograph by the American Mutoscope Company, shows a 10-inch disappearing gun at the instant of firing, and on the first page of the issue will be found views of the 8 inch disappearing gun, showing it in the loading and firing positions.



12-INCH MORTAR ON SPRING-RETURN CARRIAGE.

This fine carriage is the standard type for seacoast defence, and it is probable it will be used in all future batteries that are constructed. Other types of disappearing carriage are in service, however, notably at Sandy Hook, where a vertically disappearing form is used for some of the larger rifles. In this type the carriage, with its gun, sinks bodily out of sight into a pit, the top of the pit being covered by a large horizontal shield, which protects the crew from shrapnel or plunging fire.

The Buffington-Crozier carriage is of the front pintle form and consists of the following principal parts, viz.: The levers, the top carriage, the cheek plates or chassis, the elevating gear, the racer, the live rollers, the base ring, the transoms, the traverse wheels, the traverse circle, the traversing gear and the projectile crane.

The trunnions of the gun rest in bearings bushed with bronze, on the upper end of two cast steel levers, which are

pivoted near their middle points upon an axle of forged steel. The axle rests in bearings bushed with bronze in the top carriage, which is formed with the two hydraulic recoil cylinders in one piece of gun iron.

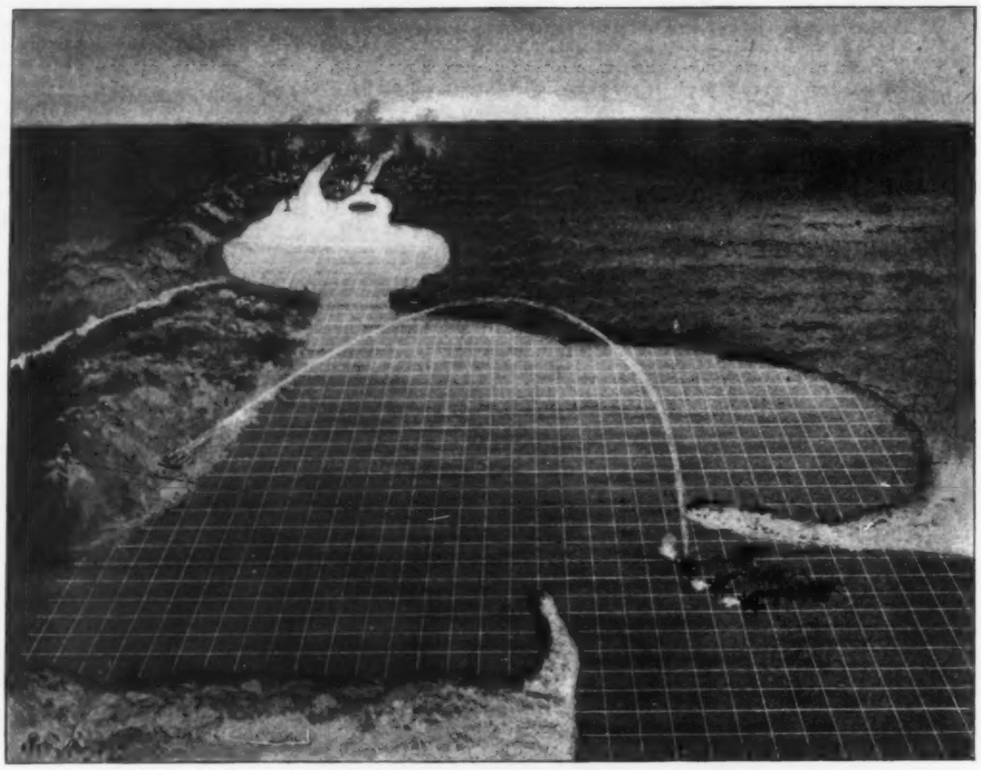
The top carriage rests upon rollers of forged steel which are placed in recesses in the cheek plates. The cheek plates are made of cast steel and are united by three transoms. Their upper surfaces have a slope of 2° to the front to facilitate the return of the piece to battery, and to reduce the preponderance of the counterweight.

The elevating rods are of forged steel, the journal bearings at their upper and lower ends being bushed with bronze. The lower ends of the rods are attached to elevating racks of bronze. The elevating hand-wheels are of wrought iron and mounted on a through shaft, upon which are pinions of bronze, gearing into spur wheels of cast steel. On the shaft with these are pinions of bronze, gearing into the elevating racks. The action of the system in recoiling is such that, no matter what elevation the gun may have when fired, it will have practically the same inclination to the horizontal—about 7°—in loading position.

The counterweight is of lead, and weighs 32,000 pounds. It is suspended by two rods from a shaft joining the lower ends of the levers.

The action of the carriage is as follows: Upon firing the piece, the central pivot of the levers moves horizontally to the rear, carrying the top carriage with it. The lower end moves vertically upward, being constrained by the crosshead guides. The gun moves downward and to the rear in the arc of an ellipse. The energy of recoil is absorbed partly by raising the counterweight and partly by the resistance of the hydraulic cylinders. After loading, the pawls are tripped and the greater moment of the counterweight enables it to raise the piece into battery. The return to battery is softened by hydraulic counter-recoil buffers in the cylinders, forming a sort of dashpot.

The piece is hauled down in the loading position by



LOCATING POSITION OF HOSTILE FLEET BY MEANS OF DEPRESSION RANGE-FINDER AND SYSTEM OF IMAGINARY SQUARES.

ONE SECTION OF A MORTAR BATTERY IN ACTION.

hand; for drill and cleaning, by a windlass arrangement, the rope leading through sheaves on the levers and chassis.

This carriage is capable of great rapidity of fire. Ten shots from an 8-inch gun have been fired from it in twelve minutes and twenty-one seconds. In the loading position the gun is completely covered from a shot

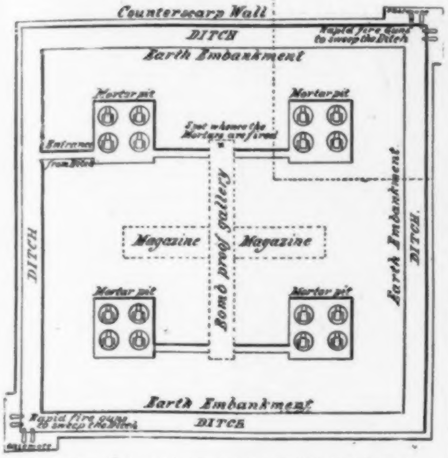


DIAGRAM OF A MODERN MORTAR BATTERY.

arriving at an angle of 7°. The field of fire is 127°, and the pointing of the gun can be varied from 12° elevation to 5° depression.

The exact distribution of these guns at the various strategic points in our harbors, for obvious reasons, is not disclosed to the public. An attacking fleet would be practically at the mercy of such a battery of disappearing guns. At the outset it would be ignorant of the location of the fort; and as we have pointed out, the use of smokeless powder would render the detection of the guns, during the few seconds that they showed above the parapet, a difficult matter. The only possible chance to place a shell inside the fort would be by making use of high angle fire; and this is impracticable in the modern warship as at present constructed, for two reasons: first, that the existing gun-carriages will not allow the breech to be sufficiently depressed to admit of such fire; and, secondly, that the existing decks are not strong enough to withstand the heavy vertical strain of the recoil. The aiming of the gun is all done under shelter. By means of a "range-finder" located on some distant eminence (see illustration, page 39), the range and azimuth (distance and direction) are found and telegraphed to the gun. The gunner then lays the piece with perfect accuracy while it is yet below the level of the parapet. Gun for gun, such a battery has an enormous advantage over the floating ship, for it has in its favor: 1. Invisibility: 2. Almost absolute protection from gun fire: 3. Absolutely steady platform: 4. Absolute determination of the range and bearing of the enemy. To this must be added the moral effect upon the courage and endurance of the gun crews, resulting from their superior protection.

Mortar Batteries.

Next in importance to the high-powered rifles (some authorities would place them first) are the mortar batteries. The element of invisibility which constitutes such a valuable feature in the disappearing gun is here attained to its fullest degree, the mortars being located permanently at the bottom of deep pits where they are at all times out of the view of the enemy.

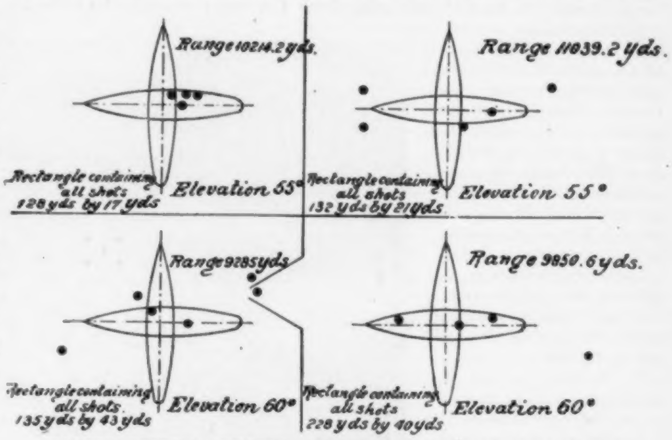
Description of the 12-inch Mortar.

In its construction the modern steel breech-loading mortar differs from the breech-loading rifle only as to length; for it is built up of tube, jacket and hoops, which are made and assembled in the manner already described at length in the earlier pages of this number. There are two types in service. The older of these is made with a cast-iron body, hooped with steel; the later model is all steel. The cast-iron mortar is cheaper to build, but it is a weaker weapon, both in itself and in its offensive power. As will be seen from the table of guns at the end of this issue, the all-steel is every way a better weapon, and it is not likely that any more of the cast-iron mortars will be built. The heavy recoil of the mortar, and the high angles at which it is fired, necessitate a special design of carriage. We present illustrations of the standard spring-return carriage, upon which most of our mortars are mounted, and of a pneumatic carriage, which is built upon the same system as the pneumatic turret-gear which is installed on the monitor "Terror."

The base of the spring-return carriage is made up of two cast-iron rings, placed one upon the other, and separated by a live roller ring of steel and wrought iron. The lower ring, termed the lower base ring, is permanently attached to the masonry by the holding-down bolts, while the upper ring, known as the upper base ring, revolves freely upon it by means of the intervening live roller ring.

The "upper carriage" consists of a transom and two side frames containing the necessary mechanism for carrying the mortar, these parts being made entirely of gun iron and attached permanently to the upper ring of the lower carriage.

The mortar is mounted on two trunnion carriages which slide on the side frames. To each of these trunnion carriages is attached a piston rod, working in a



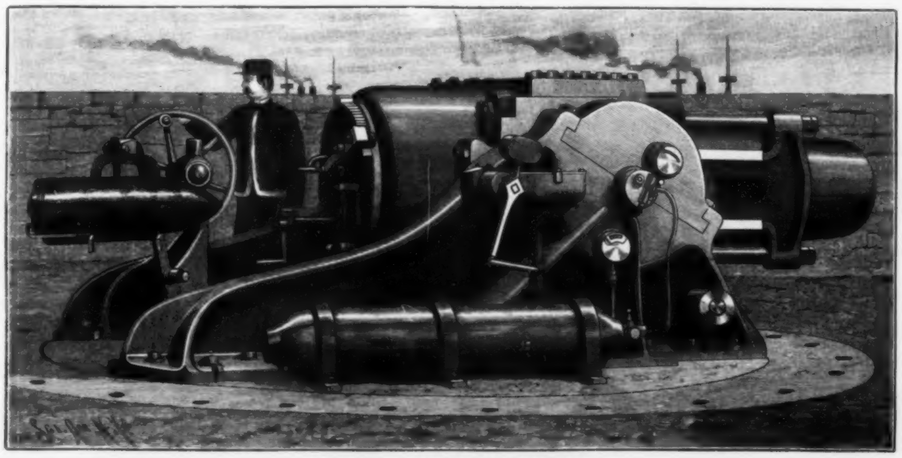
TARGET RESULTS OBTAINED IN OFFICIAL TEST OF LONG RANGE MORTAR-FIRE.

hydraulic cylinder permanently attached to the side frame. At the same time the trunnion carriages are connected by means of the compression screw with the nest of springs contained in the spring cylinders, the upper sections of which are cast into and form part of the side frames.

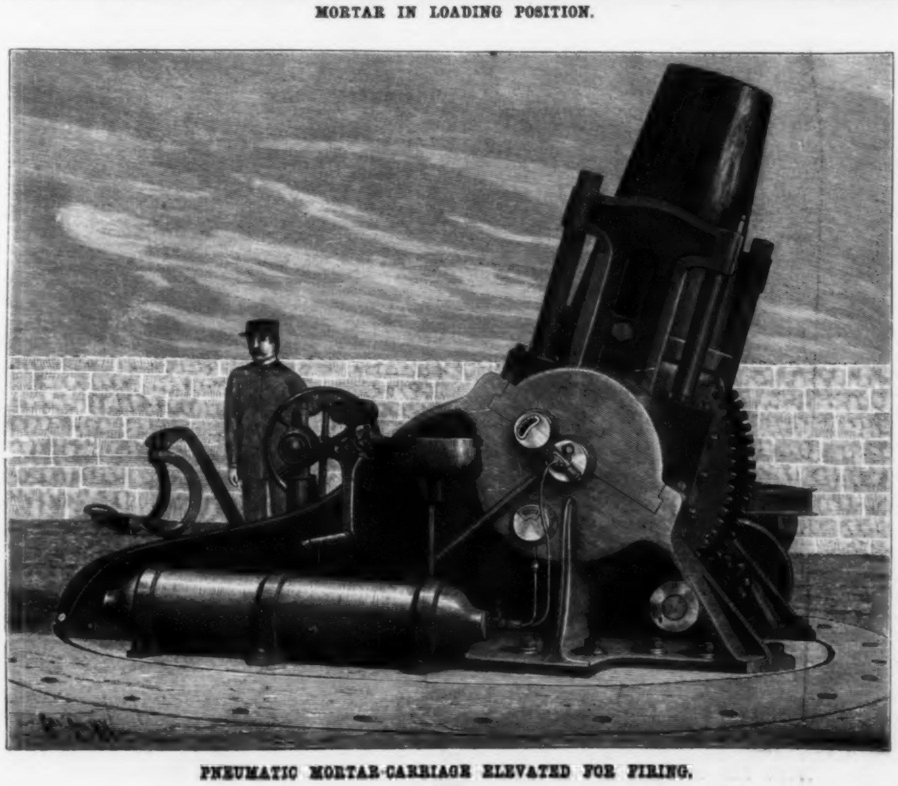
These spring and hydraulic cylinders are inclined to the horizon at an angle of 50°, and the mortar is arranged to fire only between angles of 35° and 65°, so that the force of the recoil can be taken directly by these cylinders, and but little lateral strain communicated to the upper base ring. After the recoil the elastic force of the springs will usually return the mortar into battery. Should this fail, hand bars working in ratchets cut into the side frame will accomplish the result. The training mechanism enables the upper carriage to be turned upon the lower and the mortar pointed in any desired direction.

The pneumatic carriage consists of a lower and upper racer bed, the upper circular bed supporting the two cheeks of the carriage, which is provided with heavy bearings for the reception of the trunnions.

The four recoil cylinders, 8·5 inches in diameter, are arranged in pairs on each side of the gun. They are connected by plates 2·5 inches thick, and on the sliding face between the cylinders and frames are provided with horizontal ways, 7 inches wide, with crossheads in which the outer ends of the hollow piston rods are secured; they also carry trunnion bearings for the reception of the trunnions of the mortar. At each end of the lower recoil cylinders is a 1·5 inch pipe connected to same for equalizing the pressure. The hollow piston rods, four in number, 4·5 inches in diameter, extend rearward from lugs on the sliding frame through especially prepared packed glands in the heads of the recoil cylinders, and are provided with conical valve rods, 2 inches in diameter at the large ends, whereby a portion of the air below the piston is admitted to the space above the chambered heads. When the gun is fired, the recoil is taken up by means



MORTAR IN LOADING POSITION.



PNEUMATIC MORTAR-CARRIAGE ELEVATED FOR FIRING.

of the cushion of compressed air, and the arrangement allows a sufficient amount to pass to the forward ends of the cylinders to nearly form an equilibrium of pressure on both sides of the pistons, thereby taking up the counter recoil and forming a positive elastic cushion by which the dead weight of the gun is supported.

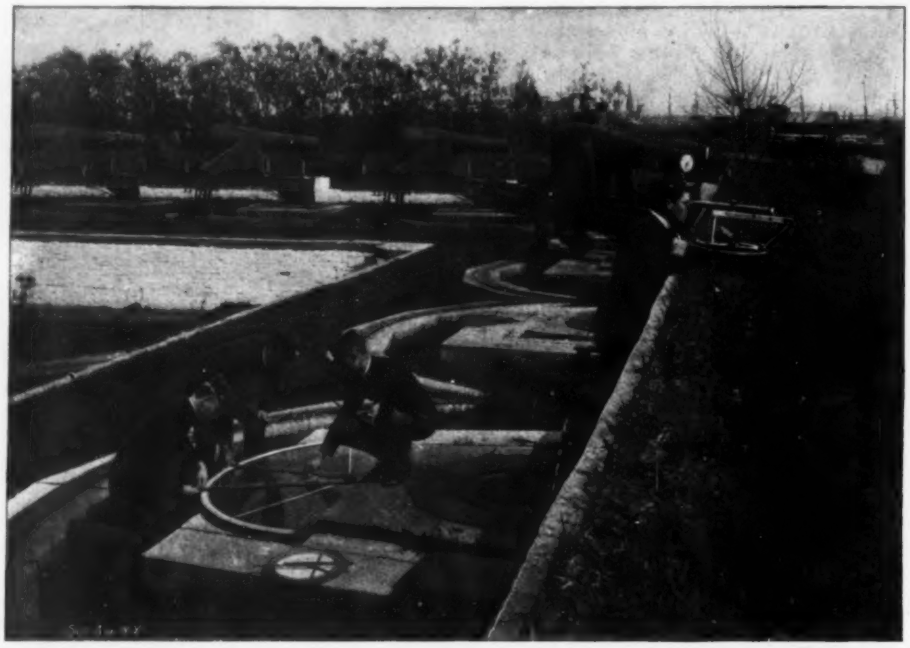
On these recoil cylinders, cast in pairs, and on the opposite side of the 2·5-inch plate from the recoil cylinders, is cast a trunnion, 30 inches in diameter, which supports the plates and the two cylinders. This trunnion fits into the side cheeks before mentioned, on which swing the mortar and recoil mechanism. At the right hand side, and in the center of this trunnion, there is a gage connection and a charging pipe which may connect with a portable or fixed receiver, charged with a suitable pressure to give 750 pounds initial pressure in the recoil cylinders.

Construction and Operation of a Mortar Battery.

In building a system of mortar batteries care is taken to place them in such positions that they can co-operate, and completely cover the channels which lead into and through the harbor. If the batteries are judiciously situated, the whole area of a harbor may be covered by mortar fire alone, and a hostile ship will no sooner pass out of the zone of fire of one battery than it will enter that of another. The site is also chosen with a view to secrecy, and it may be placed in a depression or even behind the crest of the hills that front on the harbor. This is made possible by the new system of range-finding, which renders it unnecessary for the gun detachment to see the enemy. Unlike the big rifles, the mortars are fired at great angles of elevation (35° to 65°), and obstructions which would interfere with the trajectory of a 12-inch gun would lie far below the curve of flight of a mortar shell.

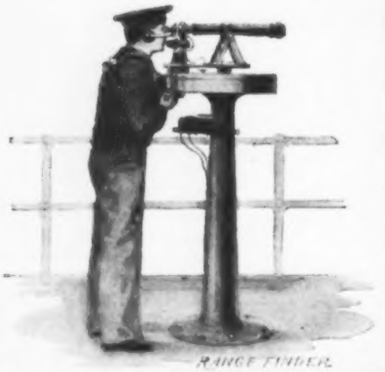
The arrangement of a 16-mortar battery is shown in the accompanying diagram and in the larger engraving, in which the observer is supposed to be looking down into one of the "pits." It consists of an earthwork containing four pits with flaring sides, which are connected by underground bombproof passages. It is surrounded by a solid counterscarp wall twenty feet high. This wall is not intended so much as a protection from the enemy's fire as to form a shield against a storming party's assault on the works. Inside of the wall, and immediately at its base, is a deep ditch. The space between the wall and the embankment would prove an awful place of slaughter for an attacking party, as at two corners of the wall are rapid-fire guns commanding all four of the trenches.

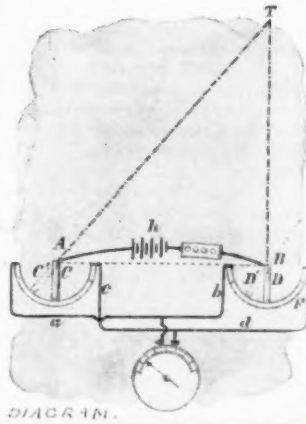
From the ditch rise great earth embankments sloping gradually to a height of 35 feet. Each of the four mortar pits is further protected by an inner wall of concrete of great thickness and a lining of steel. The pits themselves are small, being just large enough for the four big mortars. Each mortar is moved independently, and the men at the mortars can see nothing but their guns, the armored embankment and a little patch of blue sky overhead. They do not fire the mortars, nor do they see the vessel in the channel. All the officers and men have to do is to train their pieces according to the directions telegraphed



RAFFERTY RANGE-FINDER—GUN DETACHMENT WORKING OUT RANGE AND TRAVERSE (DISTANCE AND DIRECTION) ON THE RELOCATOR FROM DATA TELEGRAPHED FROM DISTANT RANGE-FINDER.

The Range-finder shown on parapet would be stationed on some distant eminence.





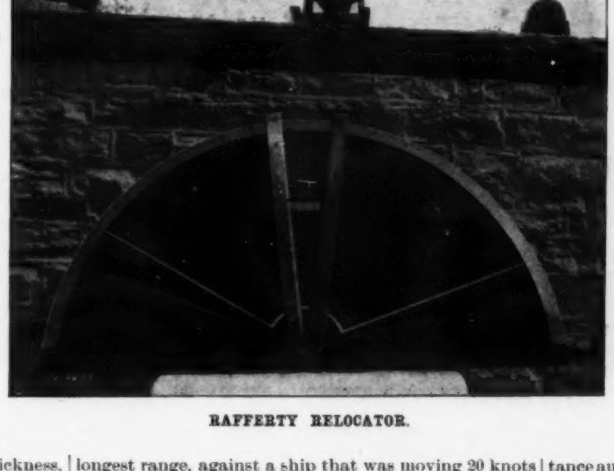
USING THE FISKE RANGE-FINDER TO DETERMINE THE RANGE OF A HOSTILE SHIP.

to them by the observers, who may be half a mile away.

The full service charge for the 12-inch mortars is 80 to 105 pounds of brown prismatic powder and a shell weighing 1,000 pounds carrying 100 pounds of high explosive. An extreme range, with satisfactory accuracy, of over six miles has been attained. Tests of these mortars have demonstrated that the fire can be so concentrated that the projectiles from a group of sixteen mortars, fired simultaneously, if desired, will fall well within the space covered by a ship's deck plan. In this connection the diagram at the top of page 35 will be of great interest. It represents the results obtained in a government test of the accuracy of our 12-inch mortars. The range varied from $5\frac{1}{4}$ to $6\frac{1}{4}$ miles, and on each occasion five shots were fired. The distances between the points at which the shots fell on each day were measured, and plotted to scale on a drawing containing the outline of the deck of the cruiser "Philadelphia." The results show that in every case the ship would have been struck, in one case by as many as four shots. Such accuracy, at a range of nearly six miles, is really wonderful, and shows how fatal would be the simultaneous discharge of a whole battery of sixteen mortars.

In this connection, also, it must be borne in mind that the shells descend almost perpendicularly upon the weakest part of the ship's armor — her protective deck. Although this is so metimes 6 inches thick at the sides, the "flats" are rarely over 3 inches in thickness, and frequently not even as much. As the 12-inch shells weigh from 800 to 1,000 pounds and are charged with high explosive and a delayed-action fuse (see cut, page 24), they would pass through the deck like so much paper and burst within the interior, possibly in the vitals of the ship. Should it not burst, a shell would pass entirely through the hull, tearing a hole in the double bottom.

The sketch at the top of page 34 is introduced to show the method by which the firing of the mortar batteries is directed. At a considerable distance from the gun, and usually in some masked position on the top of a hill, as at the point marked A, in sketch, is the range and position finder station, which is fitted with delicate and accurate instruments for determining the exact distance and position of the enemy. In addition to the range-finder, the station is provided with a chart of the harbor, the surface of which is ruled off into squares which are consecutively numbered. By means of these instruments, as will be explained in the succeeding article, the observer can determine with great accuracy the exact distance and bearing of the ship from the station. By means of a scale and protractor he determines this position on the chart and marks it by a point. Successive observations at regular intervals enable him to plot the course of the ship on the chart and determine the speed at which she is moving. He can thus determine that at a given time the ship will be at a certain square. The observing station is connected by wire with the mortar battery, and the range, position and course of the ship are promptly telegraphed down to the officer who has charge of the firing of the whole 16 mortars. The latter is located at the point marked X in the diagram. He has before him a duplicate chart to the one in the observing station. He quickly calculates at what time the ship will be at a certain square (marked with a cross in the sketch). He also knows how long it will take the shells to travel from the battery to the square (over one minute at long range), and what elevation must be given the mortar to carry to the square. The calculation quickly made, he sends to the pits the elevation and azimuth (or bearing). The 16 mortars are swung round on their tables to a common bearing, the black muzzles are raised to a common elevation; the officer stands with his eyes upon the clock, his hand on the electric button, and exactly at the predetermined moment the 16 great shells, each weighing half a ton and filled with high explosive, rise from the battery and sweep in a majestic curve to meet the advancing ship at the predetermined point in the harbor. It will interest the reader to know that if the firing took place at the longest range, against a ship that was moving 20 knots an hour, the vessel would travel nearly a quarter of a mile from the moment of firing to the moment at which the falling shells reached her deck.



RAFFERTY RELOCATOR.

Range-finders.

The accuracy of modern rifled guns is one of the wonders of engineering. Two experimental shots fired a few years ago at the same elevation from the same gun fell within thirty yards of each other, after traversing a distance of twelve miles. If a modern rifle is laid upon the target, with proper elevation and allowance for windage, it is safe to say the shot will find the mark.

The correct elevation of the gun can only be determined if the distance of the target is known; and the exact determination of the distance of a moving object is a problem that has worried the gunner ever since the day when round shot was first thrown from the sides of the wooden fighting-ship.

In the early days, the determination of the range was a matter of guesswork. The gunner assumed a distance, elevated his gun accordingly and watched the course of the shot. If it fell short, he increased the elevation, and if it passed over, he decreased it.

This was all very well in a day when the guns were too feeble to do much execution, except at close range, and a few dozen shots thrown away made little impression upon a ship's magazines. With the advent of modern ordnance, however, with its 60-ton guns and costly charges, the necessity of accurate fire became imperative, and ordnance experts set about devising some scientific method of finding the range of moving objects upon the sea.

The theory of the range-finder is based upon the well known principles of land surveying with the transit and engineer's chain. If a surveying party come to a broad river whose width has to be determined, a base-line is measured along the bank, and the angles which this line makes with a mark on the opposite bank are measured by the transit. Then, knowing the length of the base line and the two angles, the distance across the river can be determined by trigonometry.

Applying this to the range-finder, a base-line is carefully measured between two points on shore or near opposite ends of a ship, and over each point a range-finder, answering to the engineer's transit, is permanently set up. If the telescopes of the two finders are simultaneously converged upon the same point on a distant object (ship, fortress or city), the observers will be in possession of the trigonometrical data necessary to compute the distance, namely, the base and the two base angles.

Range-finders are of two types, according to the nature of the base-line upon which they work. The base-line may be the horizontal distance between two observers, or it may be the known vertical height above the sea of a single instrument located on some convenient hill or tower.

Perhaps the best known range-finder of the horizontal type is that invented by Lieut. Fiske, of the United States navy. The accompanying illustrations show this instrument as applied on board a modern warship.

In the din, hurry and slaughter of a sea fight, it would be difficult to make the necessary trigonometrical calculations, as the distances between the ships, and therefore the observed angles, keep changing; and in order to make the determination of the distance automatic, Lieut. Fiske placed his telescopes in the circuit of a Wheatstone bridge and caused their change of position to record the distance of the object on the graduated scale of a delicate galvanometer. All that was now necessary was for the observers at the two range-finders to keep the cross-hairs of the telescopes upon the same point of the ship, and the electric current translated (as it were) the angles into distances and recorded them by the movement of a needle over an arc graduated into hundreds and thousands of yards.

SIMS-EDISON DIRIGIBLE TORPEDO, CONTROLLED BY ELECTRIC WIRES FROM THE SHORE.

Our illustrations will make the operation of this most ingenious instrument clear to the reader. It represents the "Indiana" about to open fire upon a hostile ship. The converging lines are drawn from two range-finders, which are placed in elevated positions above either end of the superstructure deck. These finders are permanent fixtures, and the distance between them is accurately known. The smaller cuts show a range-finder and a diagram of the telescopes and the electrical connections.

The range-finder consists of a powerful telescope, which is mounted on a standard and is capable of horizontal rotation above a graduated disk. Upon the disk, and extending an equal distance on each side of the zero point on the graduation, is a metallic contact arc. Fixed to the telescope standards is a contact strip, which rotates with the telescope and slides over the contact arcs. In the diagram A and B represent the centers of the disks on two range-finders, and C and D the arms that carry the telescopes and contact strips, which are shown sliding in contact with their arcs. The electric current from the battery, h, passes through the centers or pivots, A and B, and then into the arcs. From the right-hand arc it circulates in the wires, b and d, from the left-hand arc in the wires, a and c, and traverses the galvanometer.

When the two telescopes are parallel, the equilibrium of the Wheatstone bridge is complete, and consequently the needle of the galvanometer shows no deflection. This equilibrium occurs, moreover, whatever be the position of the telescopes on the dial, provided that they are perfectly parallel. But if the telescope, C, for example, be turned until it is in the position, C', the parallelism being destroyed, and, along with it, the equilibrium of the two parts of the bridge, the needle

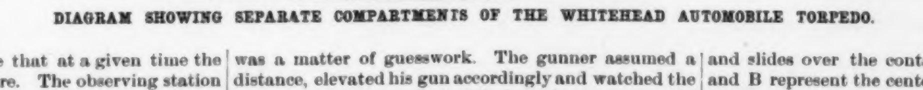
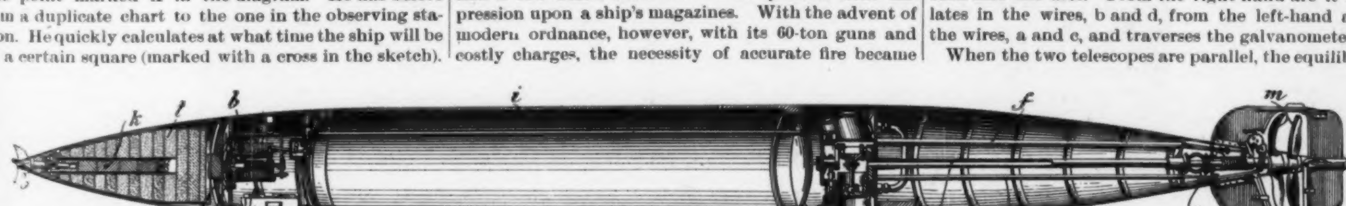


DIAGRAM SHOWING SEPARATE COMPARTMENTS OF THE WHITEHEAD AUTOMOBILE TORPEDO.



VERTICAL SECTION THROUGH AXIS OF WHITEHEAD TORPEDO.

of the galvanometer will be deflected. This deflection will increase in proportion to the length of the arc traversed by the telescope.

But since the arc, C C', is proportional to the angle at A, which is equal to the angle at T, it follows that the deflection of the galvanometer will be proportional to the angle at T, or to the distance, A T. Hence by graduating it in hundreds and thousands of yards, the distance of the ship or fort, T, may be read directly from the galvanometer. One of these galvanometers is placed in the conning tower and one at each of the principal gun stations.

It will be seen from the illustration that the operator, on applying his eye to the telescope, has opposite to his mouth a telephone transmitter, a receiver being clamped to his ear. By this means the two operators are kept in constant communication and the errors are avoided that would be caused by the reading of a deflection produced before one or other of the telescopes is well directed toward the point to be observed.

Depression range-finders, of which the Lewis and the Rafferty are the best known, have the advantage that they require only one observing station. In this case the base line is the vertical height of the instrument above the sea, the lower angle formed by this vertical with the sea level is constant, being always 90°, and the upper angle is that contained between the vertical and a line joining the instrument with the distant object. In the Lewis range-finder the angle is observed through a long telescope, which is vertically pivoted at its forward end upon the edge of a carefully leveled iron table. The telescope is also capable of horizontal rotation about the center of the table. The table is graduated in degrees, minutes and seconds, the zero point being on the meridian line; a vertical graduated arc records the angle of elevation of the telescope. In using the instrument the intersection of the cross-hairs is set on the ship at the water line, and as soon as this is done the observer can at once read off the range and azimuths—the latter being the angular distance of the object from the meridian, or its bearing. These are telegraphed to the gun; the gunner sets the sights at the range and traverses the gun carriage until it is the proper number of degrees from a meridian line marked on the traverse-table. The gun is now released, rises above the parapet, fires and sinks out of sight, driven back by the energy of recoil.

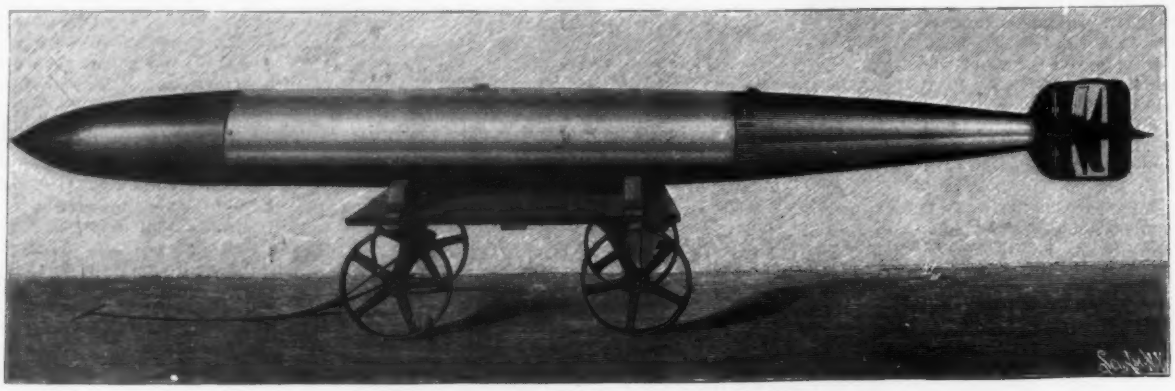
As the range-finding stations are almost invariably situated at a considerable distance from the battery, the bearing of a ship from the station will not agree with the bearing from the battery, and it is necessary to calculate the latter from the former.

To make these calculations every time the gun is to be fired at a moving object would involve a loss of valuable time, and the ordnance experts are continually aiming to shorten the process of relocating. We present two illustrations which show the operation of a relocator designed by Lieut. Rafferty, United States army, which enables these calculations to be made with great rapidity by any of the members of the gun detachment.

Lieut. Rafferty's position-finder requires the services of one observer at each end of a base line and one at the gun or guns served by it. The base line observers would be located preferably at a distance from the guns and at a moderate elevation above the sea level. They would thus be able to see vessels before they were visible from the water batteries. When a hostile ship has approached within range, both observers sight her through a telescope simultaneously, and read the bearing of the vessel from their respective positions. Having telephonic connection with the officer stationed at the relocator near the guns, each one instantly reports to him the bearing. He immediately swings one hand of the relocator to the bearing given by one observer and the other to the bearing given by the other. In the angle between the two hands he places a short rule, which bears a fixed relation to the length of the base line. He slips this rule along until it touches both hands. On the rule is a jog that represents the position of the gun. He makes a dot on the table, and having removed the rule, moves the nearest hand up to the dot. On the edge of the hand is a scale of degrees, and the vernier line that touches the dot gives the number of degrees from the north or from a line perpendicular to the parapet to which the gun must be trained.

On top of and extending the whole length of the band, or pointer, is another scale, and the reading on this scale opposite where the dot was made for the gun position shows the elevation that must be given to the piece. Having thus learned the exact train and the correct elevation, the officer orders the gun trained and elevated.

It will be understood that the range-finder is not located at the gun, as shown in our illustration, where it is introduced together with the Rafferty wind-gage, which lies to the right of the relocator, merely to show all the apparatus in one group. The range-finder shown is not the latest form of this instrument, an improved pattern being now under consideration by the designer.



SIDE VIEW OF WHITEHEAD AUTOMOBILE TORPEDO.

THE TORPEDO.

No system of harbor defence can be considered complete that does not include the submarine torpedo as part of its equipment. In our description of the dynamite gun, so called, we have seen that it is entirely practicable to throw large quantities of guncotton in aerial torpedoes with remarkable precision. The counterpart of the dynamite gun is the torpedo, automobile or dirigible, which sweeps silently and unsuspected on its course against the submerged hull of a ship, carrying, should it reach the mark, certain disaster.

The mention of the torpedo at once suggests the torpedo-boat, and it is true that torpedo defence will usually be carried out from the deck of these deadly little craft. At the same time it is possible to lay down very strong fixed torpedo defences, operated from land, especially in cases where the navigable channel runs within close proximity to the shore.

Submarine torpedoes are of two types, automobile and dirigible. The former, of which the Whitehead and the Howell are the best representatives, are self-contained, carrying their own motive power and propelling themselves independently of the firing station.

The dirigible torpedoes, such as the Sims-Edison, derive their motive power from the shore and are steered by means of connecting cables, which are paid out as the torpedo travels to its mark.

The Sims-Edison Torpedo.

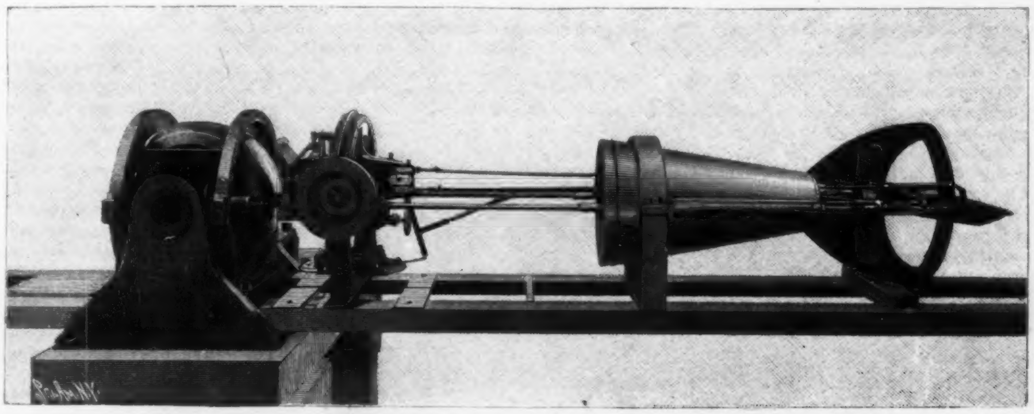
The Sims-Edison torpedo consists of a cigar-shaped torpedo and motor case which is built in four sections. The front compartment contains a charge of from 250 to 500 pounds of high explosive, which can be exploded electrically by reversing the current. In another compartment is a reel upon which is stowed from one to two miles of controlling cable. The cable is made extremely light and flexible, but of sufficient area to convey the 30 horse power necessary to drive the torpedo at a speed of 22 miles an hour.

The cable, which is connected with a dynamo at the firing station, is led out through a tube running parallel with the axis of the torpedo to a point aft of, and below, the propeller wheel. Above the torpedo proper, and rigidly connected thereto, is a float possessing the general outlines of a racing shell, and provided with two sighting poles by which its course can be observed. The hull, if desired, can be filled with cellulose or cork in order to resist the effects of penetration by shot. In actual trial it has been found to be a very difficult object to hit.

The peculiarities of its action as developed by these features are as follows: As the torpedo progresses, the cable is unwound from the reel and paid out through the tube. If the reel were on shore, the torpedo would be checked by the friction of the cable as it was dragged through the water, but by carrying the reel in the torpedo, and unwinding the cable into the

INSTANTANEOUS PHOTOGRAPH OF THE LAUNCH OF A HOWELL TORPEDO FROM TORPEDO TUBE.

water, the difficulty of friction is overcome. As the source of electric power is in the station, there is no limit, beyond that imposed by the size of the cable and electric motor, to the power which may be transmitted. The active explosive agent being contained in the submerged torpedo case, and in advance of the bow of the float, it is the first portion to come in contact with the hull of a ship The instant it touches the hull the motion of the craft will be arrested, and the electric instruments on shore will at once testify to such arrest of its course by the increased mechanical strain put upon the motor, which would at once affect the current. Finally, the raking bow connection, which is seen in the illustrations, enables the torpedo to dive under obstacles. This manœuvre has been subjected to a severe test, and the action of the torpedo in this respect has been found to be perfect.



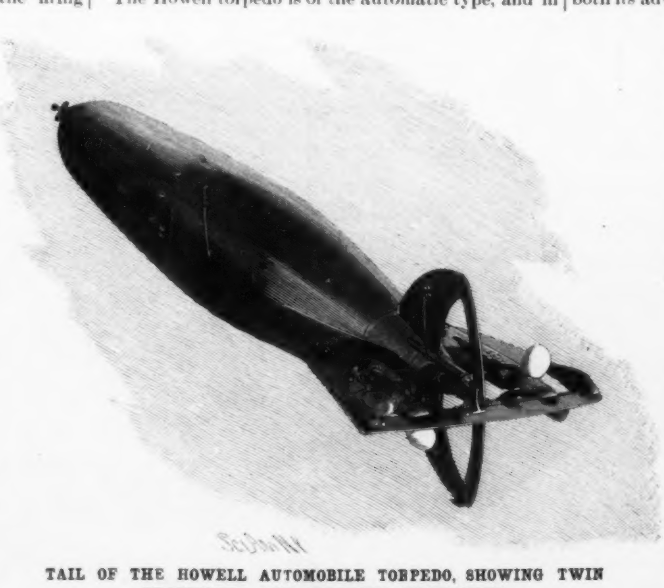
DETAILS OF THE FLYWHEEL MOTOR AND STEERING APPARATUS OF HOWELL TORPEDO.

The Whitehead Torpedo.

The Whitehead fish torpedo is the oldest, best known and most widely used weapon of its kind. It is in service in every navy of the world, and in most of them it is the only form carried. The Howell torpedo, an American invention, is its one serious rival, and the only other automobile torpedo that has proved of any practical value.

The Whitehead torpedo consists of a cigar-shaped body of phosphor-bronze or steel, divided into six separate compartments as follows: 1, the magazine; 2, the secret chamber; 3, the reservoir; 4, the engine compartment; 5, the buoyancy compartment; 6, the bevel-gear chamber.

The magazine contains the explosive charge, which consists of a series of disks of wet guncotton packed snugly together. The cartridge primer, K, for exploding the charge, consists of several cylinders of dry guncotton, packed in a tube which passes through perforations in the guncotton disks, t. The foremost of the six cylinders contains a detonating primer consisting of fulminate of mercury. The small propeller at the extreme point of the torpedo is part of an ingenious safety device for preventing premature explosion in handling. When not in use, the firing pin is held in check by a sleeve; but as soon as the torpedo strikes the water the rotation of the little propellers releases the sleeve and leaves the firing pin ready to strike the detonating primer the moment the torpedo meets an obstruction.



TAIL OF THE HOWELL AUTOMOBILE TORPEDO, SHOWING TWIN PROPELLERS AND STEERING MECHANISM.

The "secret chamber" is the most ingenious part of this most ingenious piece of mechanism. Its piston, pendulum and springs perform the important work of regulating the horizontal rudders which keep the torpedo at the proper depth. Immediately in front of the secret chamber is a narrow compartment perforated on its walls to allow the outside water to enter. The front wall of the secret chamber carries a piston, a, which can move in the direction of the axis of the torpedo. The pressure of the water is resisted by three coiled springs, as shown in the longitudinal section. At a certain predetermined depth, according to the tension on the springs, the springs and water pressure will be in equilibrium; below that depth the piston will be driven in by the water pressure, and above it the springs will push forward the piston. To prevent too sudden oscillation in this action, the piston is connected to the rod, e, of a swinging pendulum, d. The motion of the piston is communicated by rods, which pass through the hollow stay rods of the air chamber to the horizontal or diving rudders. If the torpedo goes too deep, the piston moves back, the pendulum swings forward, and the rudders are elevated, the reverse movements taking place if the immersion is not sufficient. When a torpedo dives into the water, the first part of its run is made on a wave line which crosses and recrosses the desired and ultimate level of immersion, the piston and the pendulum gradually bringing the torpedo to a true course. The reservoir forms the central body of the "fish." It is made of forged cast steel and is tested up to 70 atmospheres. A tuyere at its after end feeds the air to the engine.

The torpedo is driven by a three-cylinder engine, with cylinders 120° apart, acting on a common crank. The engine is started by means of a valve which is opened by a lever striking a projecting lug on the launching tube, when the torpedo is fired.

The buoyancy chamber is an air-tight compartment, the purpose of which is to afford the proper buoyancy to the torpedo; it carries a piece of lead ballast, by shifting which the trim can be controlled. The two tubes, f and g, carry the connecting rods for controlling the horizontal diving rudders.

Next comes the bevel gear chamber, where is located the gear, l, for causing the propellers, m, to rotate in opposite directions. The after propeller is keyed to the main shaft; the forward propeller is keyed to a sleeve which rotates freely upon the main shaft, and the motion is reversed by means of two bevel-wheel gears which turn on a spindle at right angles to the main shaft. The "tail" consists of a stock with vertical vanes, which act as the vertical rudder, and two frames which carry the horizontal rudders.

The Whitehead is fired from a launching-tube by the explosion of a small charge of gunpowder behind it. This compresses the air which surrounds the rear half of the torpedo and thrusts it out of the tube without any serious jar.

The range and speed of the Whiteheads vary with the size. The latest 14-inch weapon is 15 feet in length, carries 90 pounds of guncotton, and has a speed of 28 knots for a range of 800 yards. The 18-inch torpedo of 1895 is 16 feet 7¼ inches in length, carries a charge of 175 pounds of guncotton, and has a speed of 31 knots for 1,000 yards.

The Howell Automobile Torpedo.

The Howell torpedo is of the automatic type, and in this respect it resembles the Whitehead and its later modification, the Schwartzkopf. Beyond the fact that it is automatic, however, there is little resemblance, the diving and steering mechanism of the Howell being of an entirely original type.

Motive power is furnished by a heavy flywheel, which is carried at about the mid-point of the length of the torpedo upon a steel axle, whose axis lies horizontally and at right angles to the long axis of the torpedo. The launching is effected from a torpedo tube, as shown in the accompanying cut. To the outside of the tube is bolted a motor, by which the flywheel is run up to the desired speed. A hole pierces the tube opposite the end of the flywheel axle, and through this a clutch on the motor moves to engage a corresponding clutch on the end of the flywheel axle within the torpedo. As the axle of the flywheel lies horizontally in the sectional plane of the torpedo, the high speed of revolution of the wheel gives great gyroscopic stiffness, or a resistance to being turned out of its plane, to this axle. The torpedo thus possesses internal directive force, and projected on any course tends to maintain its horizontal direction with great persistence. Its action in this respect corresponds to the tendency of a rifled projectile to maintain its direction with point forward. At the same time the torpedo, after discharge, is perfectly free to turn vertically, and therefore may be readily steered up or down to any desired depth.

Unlike the Whitehead, the Howell carries its two propellers side by side. The propeller shafts are geared directly to the flywheel by means of bevel-wheels.

The torpedo is maintained at its proper depth below the surface by an arrangement which is similar to that in use on the Whitehead. In a chamber immediately behind the flywheel chamber (see photograph of details) is a hydrostatic piston which regulates the depth, and a pendulum which controls the angle of ascent or descent. The piston and the pendulum are connected with the tiller of the diving rudder in such a way that neither of them is affected by the action of the other, although the movement of the tiller is controlled by the action of both. The necessary force for throwing the rudder up or down is taken from the revolving propeller shafts. The speed of the torpedo is maintained at a constant rate by an ingenious arrangement that alters the pitch of the screws as the torpedo travels on its course. At the commencement of its journey, when the flywheel is at its maximum speed, the screws have a fine pitch; but as the wheel—and consequently the propellers—loses its speed, the pitch of the screws is automatically increased, with the result that an even rate of travel is maintained. The average Howell torpedo is somewhat smaller than the 14-inch Whitehead.

As compared with the Whitehead, the Howell has both its advantages and its disadvantages. Its disadvantages are that it takes considerable time to spin the flywheel up to the desired 9,000 revolutions, whereas the Whitehead is always ready for launching. The speed and range, moreover, of the latter are greater. On the other hand, the Howell carries a relatively larger charge of explosive, and, in the important feature of ability to maintain its true rectilinear direction, it is greatly superior.

Our readers will be interested to know that our leading battleship, the "Iowa," is provided with four launching tubes for this type of torpedo.

SUBMARINE MINES.

We have seen that, in its endeavor to force its way into a properly defended harbor, a fleet would be subjected to various forms of attack. At a distance of six or seven miles it would be within the zone of fire from long-range 8 and 10-inch rifles, whose high-explosive shells, while they could not pierce heavily armored sides and turrets, would do deadly execution against unarmored ends, and, by virtue of their plunging effect, against the unarmored decks. At a closer range of from three to six miles the deadly rain of mortar-shells would begin to fall like thunderbolts from a clear sky, crashing through the protective decks and bursting within the vitals of the ship. At closer ranges of 4,000 yards and under (should the fleet have survived the earlier attack), the masked batteries of 12-inch guns would open fire against the water-line belts and barbettes, which would be easily penetrable at these ranges; and this fire would be supported by the fire of 10 and 12-inch guns mounted on the harbor monitors. From sheltered bays and headlands the torpedo boats would lie ready to make a dash upon the enemy, who would be already disorganized by the concentrated fire to which he was exposed; and from heavily protected stations on shore the dirigible and automobile torpedoes would

be silently dispatched to attack the submerged portion of the hull.

After this enumeration of the destructive agencies which would contest every foot of a hostile advance, it would seem that a modern system of harbor defence is impregnable. And yet we have thus far taken no note of what many authorities believe to be the most effective defensive weapon of them all—the submarine mine. It is scarcely necessary to dwell upon the tremendous moral and material effect of this form of attack, in which the element of secrecy is so perfectly realized. The moral effect is so strong that the mere fact that a channel *may* be mined, will usually be sufficient to keep a fleet from attempting its passage; the material effect, should a ship be caught within the radius of explosion of a powerful mine, would be its certain destruction.

Submarine mines are of three different kinds: 1. Observation mines, which are fired from shore when a ship is judged to be within range. 2. Automatic mines, which are self-firing on being struck by a ship. 3. Electrical-contact mines, which, on being struck by a ship, give notice to the operator, who, by the throw of a switch, fires the mine.

Generally speaking, submarine mines consist of a metal case, which is filled with a charge of high explosive and contains a fuse that may be fired either automatically or at will by an observer on shore. Broadly speaking, they may be divided into ground mines and buoyant mines, according to their depth of submersion. Where the depth of water is not too great to interfere with the destructive force of the explosive, the mine is placed on the bottom, and is known as a ground mine; in deeper water it is placed in a buoyant cylinder or sphere, which is anchored to the bottom and floats at the desired depth below the surface. The buoyant mine has an advantage over the other type in the fact that it lies nearer the object of attack, and, therefore, does not require to be filled with such a heavy charge of explosive.

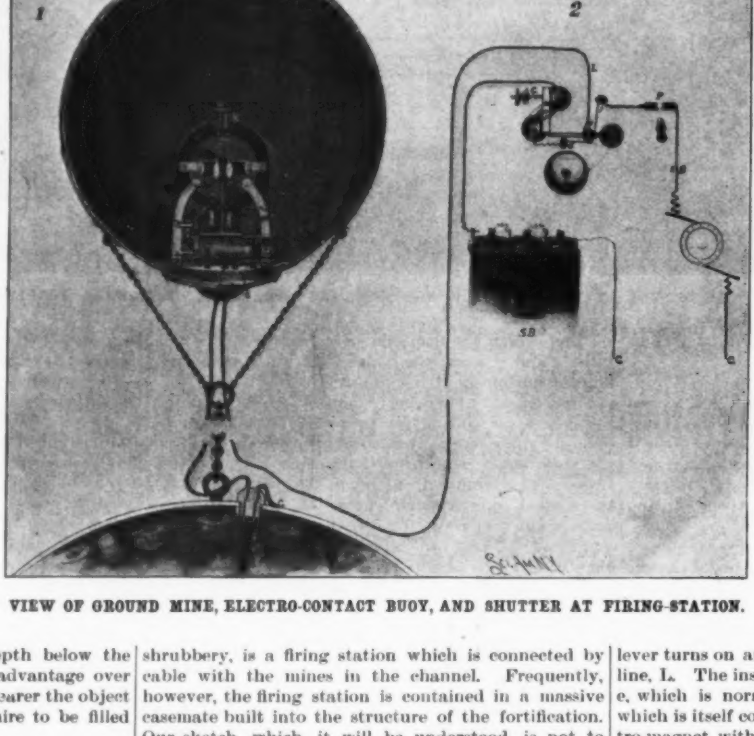
Observation mines may be fired by one or two observers. If by one observer, the mines are laid down in rows, the lines of which converge to the observation station. All the mines in one row are connected so that they can be simultaneously fired when the ship is passing the range line. When the mines are connected with two observers, they are laid according to a system of cross observation, by which it is possible to fire any particular mine when the ship is above or in close proximity to it.

The most common type, and unquestionably the most certain in its action, is the electro-contact mine, in which the charge is exploded either directly when the mine is struck by a ship, or at the will of the operator on shore, on his receipt of a signal automatically transmitted from the mine at the moment of contact. The electro-contact type may be either buoyant or ground mines, according to the depth of the water in any particular location.

In the accompanying sketch we show a system of electro-contact ground mines laid across a channel, with a battery of rapid-fire guns on shore commanding the whole of the mine-field. On the slope of the hill above the rapid-fire battery is a battery of 8, 10, and 12-inch high-powered rifles, and above this, hidden by shrubbery, is a firing station which is connected by cable with the mines in the channel. Frequently, however, the firing station is contained in a massive casemate built into the structure of the fortification. Our sketch, which, it will be understood, is not to scale, shows a single line of mines only, laid across the channel. As a matter of fact, there would be several parallel lines, and they would be so laid with regard to each other that the mines in each line would cover the spaces left in the lines adjoining, with the result that, on whatever course a ship might be steering, she would be certain to strike one or more of the mines before she passed through the field.

The complete mine consists of a heavy, cast iron, hemispherical case, containing from 200 to 500 pounds of guncotton, dynamite, or blasting gelatine, which rests on the bed of the river or channel, and is held in place by heavy claws or hooks, which are cast upon the shell for this purpose. Attached to the mine and floating above it is a hollow, buoyant sphere, in which is placed the electric circuit-closer. Wires lead from the buoy to a fuse in the ground mine, and to the signal station.

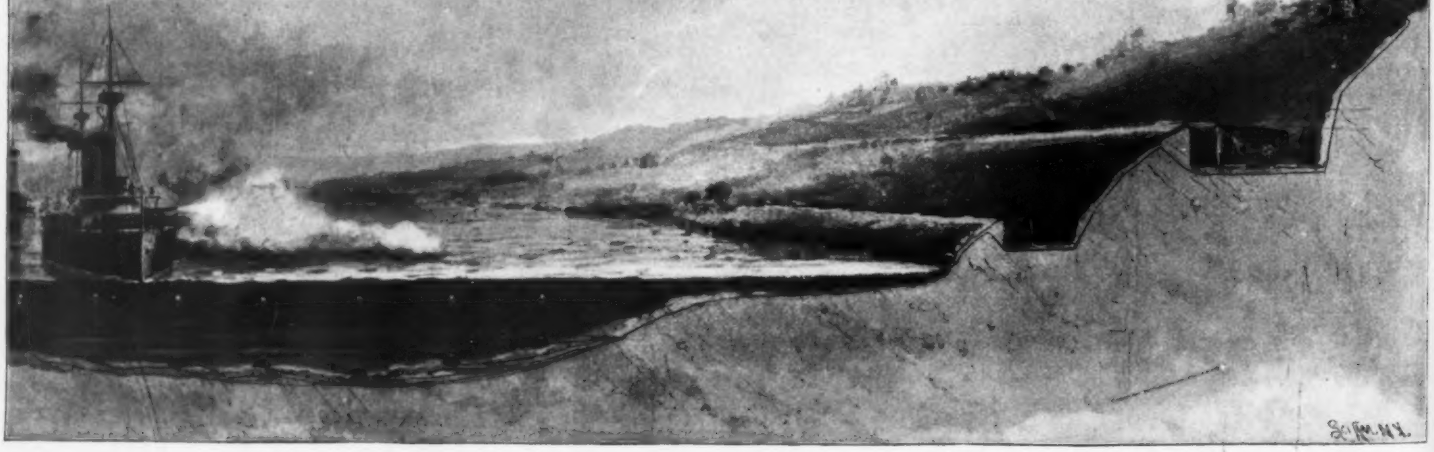
In the accompanying figure we show a type of circuit-closer designed by Col. Bucknill: It consists of a horseshoe magnet, M, M, within which is hung by a coiled wire a ball, B. A silken cord is hung to the top of the magnet, passes down through the ball, and is attached to an armature, A. When the vessel strikes the buoy, the ball is thrown to one side, draws aside the silken cord and lifts the armature, A. To the poles, N, S, of the magnet are secured two small magnets, C, C, one end of the coil wire being connected to line and the other to a contact point, b. The armature, A, is secured by a spring to an isulated point, P, from which a wire passes through the firing fuse in the ground mine to earth. The other end of the armature carries a contact point which, when the buoy is struck, engages with a contact point, b, which is connected to earth through the interposed resistance of a 1,000 ohms resistance coil.



VIEW OF GROUND MINE, ELECTRO-CONTACT BUOY, AND SHUTTER AT FIRING-STATION.

Fig. 2 shows the automatic indicator or shutter which is placed in the firing station on shore. Two currents are employed: One, a continuous current of feeble power from a signaling battery, S B; the other and more powerful current from a firing battery, F B. The arrangement is as follows: Between two electro-magnets, b b, is suspended an armature, a, pivoted at its center, p. The lower end of the armature holds one end of a weighted lever, 4. When a current passes through the magnets the armature is rotated, the end of the weighted lever released and the weight falls, striking a bell and giving notice to the operator. The weighted lever turns on an insulated axis which is connected to line, L. The insulated axis carries a metallic cross-bar, e, which is normally in contact with the spring, d, which is itself connected through the coils of the electro-magnet with the signaling battery, S B. When the weighted lever, 4, known technically as the "shutter," falls, this spring is disconnected by the rotation of e, and the firing battery, F B, is brought into play through the contact of plate, e, with spring, f, that is, supposing the plug, P, is in place. By leaving P normally out of place, the observer can fire the battery at will by inserting the plug.

Now let us follow more closely the operation of blowing up the hostile ship. The instant the vessel strikes the buoy, the suspended ball, B, swings to one side, draws aside the cord, pulls up armature, A, into contact with b, and causes the signal-battery current to pass by way of the 1,000 ohms resistance-coil down through the ground mine fuse to earth. This current



Field of ground mines, showing electro-contact b oys attached. Rapid-fire battery to prevent countermining. Battery of 8, 10, and 12-inch disappearing guns. Firing station and range-finders.

SKETCH SHOWING METHOD OF DEFENDING HARBOR CHANNEL WITH SUBMARINE MINES RAPID-FIRE BATTERIES AND HIGH-POWERED, DISAPPEARING, BREECH-LOADING RIFLES.

is too weak to ignite the fuse. At the same time the armature, a (in the firing station), is attracted to the magnets, b, b, and releases the pivoted shutter, 4, ringing the bell and throwing the signal battery line, L, into circuit with the line to the firing battery, F B. The operator now places the plug, P, in place, and sends the whole force of the main current into the line, and as this has sufficient force to pass the resistance and ignite the fuse, the ground mine is instantly exploded.

No mine field is complete, or can ever be thoroughly effective, unless it is protected by rapid-fire guns. It is possible for small boats, launches, etc., to be sent forward ahead of the ships, and set off the mines by exploding large charges of dynamite in the mine field. If the mines are within the "sympathetic radius" of the explosions, they will be exploded by the shock. The most effective protection against such countermining, as it is called, is by flanking the field with batteries of rapid-fire guns in the manner shown in the accompanying sketch.

In concluding the series of chapters on harbor defence, we would draw attention to the fact that it is only when all the various elements of guns, mortars, monitors, torpedo boats, torpedoes, submarine mines, and, above all, reliable range-finders, are provided, and provided in abundance—then only is it that a city can be pronounced impregnable. We have heard much talk of late in the daily press about our impregnable defences. It is not for us to state how far they are, or are not, up to the standard of completeness which would justify such cities as New York, Boston, Philadelphia, or San Francisco in settling down into a sense of comfortable security. This much, however, is certain: That when the present war is ended, public sentiment will not be satisfied with anything less than the immediate completion of our coast defences on the excellent lines laid down many years ago by our army officers.

The enlightenment of the public as to the exact state of our defences has been one of the healthy effects of the war, and we doubt not that, when our Congressmen are called upon once more to vote appropriations for guns, mortars and their emplacements, they will act with a more thorough knowledge of existing necessities than heretofore.

THE ARMY OF THE UNITED STATES.

Twice in the history of the world we have had an example of large bodies of men who were not producers, who disturbed economic conditions by living at the public expense. We refer to the enormous monasteries in the middle ages and to the standing armies in Europe to-day. It seems to be essential to the maintenance of the integrity of a number of the countries of Europe to keep a large standing army—an army which takes some of the best years of the life of its citizens, as service is obligatory to all. These armies are supported at an enormous expense by systems of taxation which affect the poorest as well as the richest. Germany has in her active army a reserve of 2,140,352 men. This number may be increased in war time by well trained reserves until she would have a grand total of 68,412 officers and 5,198,180 men. France is not far behind Germany as regards militarism, as she has 2,071,980 officers and men in the active army, and on a war footing she would have 4,849,572 men. Then come Russia, Austria-Hungary, Italy and England, each with an army numbering hundreds of thousands, so there are on a peace footing over 7,500,000 men in the army in six countries of Europe. The question of the standing armies of Europe is a problem which is rapidly increasing in seriousness, and there does not appear as yet to be any solution of the difficulty.

In the United States, owing to our isolated position and the absence of powerful neighbors, it has not been found necessary to have a large military establishment such as is required abroad. For many years it has seemed impossible that we should become embroiled in international complications. For a long time the navy has monopolized public attention, but when peace was hanging, as it were, by a thread, the army was immediately brought to public notice, and it was found we had but a small, but well-drilled, body of troops ready for service. It should be remembered, however, that the regular army is only a nucleus which may be expanded in time of war.

The present war has made it manifest that the size of our Regular Army has not been adequate, and that the time has been reached in our national growth when the army should be definitely increased to a size proportionate to the vast population of the country.

The bill recently increasing the size of the army from 27,000 to 62,000 men is of little avail as touching this problem, as it only provides for an army of that size during time of war. War almost always comes suddenly, often unexpectedly, and the bill would not relieve us from the helplessness we have been exposed to in the past. For our protection we have to rely upon:

1. The Regular Army, which represents and is under the pay of the federal government, and which is officered almost entirely by graduates of the West Point Military Academy. The officers receive commissions at the hands of the President:

2. The National Guard, which is composed exclusively of State troops, and is under the command of the Governors of the respective States. The officers of higher grade are appointed by the Governors, but the other officers, from Colonel down, are generally selected by ballot by the troops themselves. The National Guard is intended primarily for home defence:

3. The Volunteers, which form a branch of the service only to be found in time of war. They are such as offer their services upon the call of the President, and are officered either by West Point graduates, by officers of the National Guard, or civilian appointees.

Under the conditions existing in the present war the members of the National Guard were not called upon to serve in their capacity as State troops, but were invited to enlist in the volunteer service.

The term of enlistment in the regular service is for a period of three years, which term is fixed and not terminable by the ending of the war. In the volunteer service the period of enlistment is two years, but this term may be shortened by the ending of hostilities.

The officers of the regular army are graduates of the United States Military Academy at West Point, New York. Each Congressional District and Territory, as well as the District of Columbia, is entitled to have one cadet at the Academy, the nominations being made by the Representative. There are also ten other appointments at large, which are usually conferred on the sons of officers in the army or navy by the President of the United States; therefore, the number of students is limited to 371. Foreign governments can have cadets educated at the Academy by authorization of Congress. The nominations to the Academy are usually made by the Congressman after a competitive examination, though they may be given directly by the Representative. Appointees to the Military Academy must be between the ages of seventeen and twenty-two years, of sound health, and free from any infirmity which may render them unfit for military service. The candidates are sent to the Military Academy at West Point, N. Y., where they pass a thorough examination in reading, writing, arithmetic, grammar, geography, history, etc. The course of instruction requires four years, and is largely mathematical and professional. The discipline is very strict, even more so than in the army. From the middle of June to the end of August the cadets live in camps and receive practical military instruction. While the cadet is obtaining his education he receives $540 per annum, which is sufficient for his support. After graduating, the cadets are commissioned as second lieutenants in the United States army.

Before the present war with Spain the regular army of the United States consisted of 27,532 men—2,179 officers and 25,353 enlisted men. On June 30, 1897, the distribution was as follows:

	Officers.	Enlisted men.	Total.
Twenty-five infantry regiments.....	910	12,871	13,781
Five artillery regiments..............	290	3,934	4,224
Ten cavalry regiments..............	447	6,010	6,457
Engineering battalion, ordnance departments, hospital service, Indian scouts, West Point Military Academy, Signal Service, recruiting parties and marines....	532	2,538	3,070

There were three Major-Generals—Miles, Merritt and Brooke, and six Brigadier-Generals, Otis, Coppinger, Shafter, Graham, Wade and Merriam—in addition to the departmental officers detailed for duty at Washington.

On April 23, 1898, Congress passed a bill reorganizing the army. This enactment provides that all infantry regiments shall consist of three battalions instead of two, and that all arms of the service are to be recruited up to their full strength. It will be seen by our figures that the twenty-five infantry regiments had only 12,871 enlisted men a year ago. When the skeleton organizations are recruited to their full strength under the new law the infantry will number 31,800, the cavalry 12,000, the artillery 16,457 and the engineers 752; with the officers the total will be 62,000.

The bill reorganizing the army provided for 25 majors, which are to be a permanent addition to the officers of the regular army; 150 commissioned officers, to provide for the companies in the 3 battalions of each of the 25 regiments of infantry; and 84 second lieutenants, being one for each of the 84 batteries of artillery when recruited to their full strength.

The commander-in chief is, of course, ex-officio, the President of the United States. The Secretary of War is the Hon. Russell A. Alger, and the Assistant Secretary of War is the Hon. George D. Meiklejohn.

Like the grades of Admiral and Vice-Admiral, the army also has two grades which are not at present filled—General and Lieutenant-General. We have had only four Generals, Washington, Grant, Sherman and Sheridan. A General is supposed to command an army. At present there are no Generals or Lieutenant-Generals in active service, but the ranking general, Major-General Miles, commands the army. An army is a large and organized body of soldiers generally composed of infantry, artillery and cavalry, completely armed and provided with necessary stores, etc., and the entire force is under the direction of one general, who is called the "general-in-chief." The army is subdivided as follows; the grades of rank and commands appropriate to each grade are given.

An "army" is divided into two or more corps commanded by a Major-General. A "corps" is the largest tactical unit of a large army. A corps is usually organized with separate staff, infantry, cavalry, and artillery regiments as well as auxiliary services, so that it is really a small army complete in itself. A corps is usually composed of three divisions, each commanded by a Major-General or a Brigadier-General. A "corps" is also any body or department of an army which is not detached, but has its own organization and head, as the "Corps of Engineers." Each "division" is composed of three brigades, and there may be an independent brigade of cavalry or artillery.

A "brigade" consists of three regiments, though there may be more, and it is commanded by a Brigadier-General, and sometimes by a Colonel. A "regiment," which is the administrative unit, is commanded by a Colonel, and it is divided into a number of companies, from ten to twelve in number, each composed, under the present law, of 106 men for the infantry, 100 men for the cavalry, 200 men for heavy artillery, 173 men for light artillery and 150 men for the engineers. A "company" is commanded by a Captain. Two or more companies form a "battalion," and the battalion is commanded by a Major.

The relative rank between the officers of the army and navy is as follows: General with Admiral; Lieutenant-General with Vice-Admiral; Major-General with Rear-Admiral; Brigadier-General with Commodore; Colonel with Captain; Lieutenant-Colonel with Commander; Major with Lieutenant-Commander; Captain with Lieutenant; First Lieutenant with Lieutenant (junior grade); Second Lieutenant with Ensign.

The pay of the officers in active service is as follows: Lieutenant-General, $11,000; Major-General, $7,500; Brigadier-General, $5,500; Colonel, $3,500; Lieutenant-Colonel, $3,000; Major, $2,500; Mounted Captain, $2,000; Captain on foot, $1,800; a regimental Adjutant, $1,800; regimental Quartermaster, $1,800; First Lieutenant, mounted, $1,600; First Lieutenant on foot, $1,500; Second Lieutenant, mounted, $1,500; Second Lieutenant on foot, $1,400. All of the officers from the Colonel down receive additional amounts after five, ten, fifteen and twenty years' service, but there is a limit to this amount; thus the maximum pay of a Colonel is $4,500 per annum. The pay of a private, whether artillery, cavalry or infantry, is $13 per month for the first and second years, $14 for the third year, $15 for the fourth year, $16 for the fifth year. After five years' continuous service they receive $2 per month extra. During this war 20 per cent is added to the pay of all enlisted men (but not to that of officers).

The policy of the United States in having a small military establishment has led to the organization of a large body of reserves, which are known as the "National Guard." According to the latest accounts received at the office of the Adjutant-General in 1896, there were in the National Guard of the various States and Territories 9,376 commissioned officers and 106,251 non-commissioned officers, privates, musicians, etc., making a total of 115,627, and the number is now somewhat greater. It is entirely optional whether eligible citizens join the National Guard or not, and they elect their own officers, but it is safe to say that this body of reserves is recruited from the best and most patriotic element of the population of the United States. Congress makes an appropriation each year for the support of the militia in the various States, and the States also afford help and build armories, in order that the troops may be well drilled, as the regiments are really intended to defend their own States primarily, although in time of war they furnish an excellently drilled body of volunteers. In nearly every city of any great size there is one or more armories, and in the smaller cities and towns there are separate companies which have armories or drill halls. The militia in each State is divided into brigades, regiments and companies. It has now been decided that the President of the United States has the power to call upon any of the military organizations of the States, but usually the request for troops is made by the Governor of the State. The National Guard, or the "militia," unlike the regulars, are a familiar object to all those who live in cities, and it is probable that the present war will demonstrate the efficiency of this method of procuring a large addition to the regular military force.

On April 23, 1898, Congress passed a bill authorizing a temporary enlargement of the army during any war and giving to the President of the United States the power to call for volunteers, and on April 23 he issued a proclamation calling for 125,000 volunteers, to serve for a term of two years unless sooner discharged. After the battle of Manila and the bombardment of San Juan it was thought that it would be wise to ask for a second body of volunteers, so on May 25 the President called

SOME PROMINENT GENERALS OF THE UNITED STATES ARMY,

1898

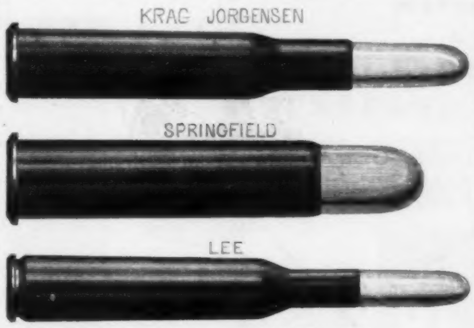
for 75,000 additional volunteers. Some of the men accepted were not members of any regiment or troop, but on April 25 a telegram was sent to every Governor giving the quota expected from the State. It was the President's wish that the National Guard or State militia should be used as far as their number would permit, for the reason that they were organized, equipped and drilled. The National Guard responded promptly, and most of the regiments are now mustered into service.

Some of the regiments were of a special character, as the Roosevelt "Rough Riders," which have displayed so much bravery in the advance on Santiago, and the "Astor Battery," made up of carefully selected men and equipped with mountain cannon. A number of professional men, engineers, civil, electrical and mechanical, have organized a regiment to be composed of practical men in all branches of mechanics. The officers of the National Guard are elected in time of peace by the men composing the regiment, and in the present emergency in nearly every case these officers were retained. The higher officers, Brigadier-Generals, etc., were appointed by the President, and were taken from West Point graduates, the State militia or civil life. The lower officers of the volunteers who were unattached to a military organization were taken from civil life.

In the latter part of April the concentration of the troops began at Chickamauga, Ga., Mobile, Ala., Tampa and Key West, Fla., and at San Francisco, and troops have now been dispatched to the Philippines and Cuba. Some of the regiments sent to the places of rendezvous did not have quite the full number of companies (twelve), and as many of the companies were not recruited up to their full strength (109 officers and men), the War Department decided to place the first 25,000 men enlisting after the second call in existing organizations, to bring them up to their full strength before any new regiments were formed. In addition to the men already called for, provision was made for enlisting 10,000 "immunes," or soldiers proof against yellow fever, 3,000 cavalry and 3 regiments of engineers. When the regular army is recruited to its full strength, 62,000, there will be a force of 278,500 men under arms.

Between May 4 and June 9, the President appointed twelve Major-Generals of volunteers. Seven of these were Brigadiers: Joseph C. Breckinridge (Inspector-General), Elwell S. Otis, John J. Coppinger, William R. Shafter, William M. Graham, James F. Wade and Henry C. Merriam. Five of the new Major-Generals were taken from civil life, but had seen service during the late civil war: James H. Wilson, of Delaware, and J. Warren Keifer, of Ohio, had been in the Union army, and Fitzhugh Lee, of Virginia (lately Consul-General at Havana), Joseph Wheeler, of Alabama, and M. C. Butler, of South Carolina, were Confederate generals.

Sixty-nine Brigadier-Generals of volunteers were appointed also during the six weeks prior to June 14. Of these, twenty-seven had been Colonels in the regular army. Fourteen Lieutenant-colonels were made Brigadier-Generals. Major-General Nelson A. Miles is in command of the whole army. General Merritt, with General Otis next in command, has been assigned to the Philippines. General Brooke was placed in charge of the First Corps, with headquarters at Chickamauga; General Graham, the Second Corps, Falls Church, Va.; General Wade, the Third Corps, Chickamauga; General Coppinger, the Fourth Corps, Mobile; General Shafter, the Fifth Corps, Tampa (General Shafter is now in Cuba with the troops); General Wilson, the Sixth Corps, Chickamauga; General Lee, Seventh Corps, Tampa; General Wheeler, Cavalry, Tampa (now in Cuba). General Breckinridge was kept busy for some weeks with inspection duty. General Merriam on the North Pacific Coast, and Generals Keifer and Butler had not been especially assigned up to June 10.



STANDARD U. S. CARTRIDGES.
(ACTUAL SIZE.)

In October, 1897, the departmental officers were as follows:

Adjutant-General	Brig.-Gen. Samuel Breck.
Inspector-General	Brig.-Gen. Joseph C. Breckinridge.
Quartermaster-General	Brig.-Gen. G. H. Weeks.
Commissary-General	Brig.-Gen. William H. Bell.
Surgeon-General	Brig.-Gen. George M. Sternberg.
Paymaster-General	Brig.-Gen. Thaddeus H. Stanton.
Chief of Engineers	Brig. Gen. John M. Wilson.
Chief of Ordnance	Brig.-Gen. Daniel W. Flagler.
Judge Advocate-General	Brig.-Gen. G. N. Lieber.
Chief Signal Officer	Brig.-Gen. Adolphus W. Greely.
Chief Record and Pension Officer	Colonel F. C. Ainsworth.
Public Buildings Superintendent	Colonel T. A. Bingham.

Such is, in brief, the organization of the army which is now fighting our battles. One of the advantages to be derived from the present war will be the lesson taught in regard to our military system. We are now enabled not only to clearly perceive the absolute necessity of adequate military organization and preparation for both the army and the navy, but we are in a position to obtain information which will enable us to perfect this organization in the only manner by which it can be made thoroughly efficient, which is experience in actual warfare. It is estimated that we have 10,000,000 men in the United States who are available for military duty, and the War Department keeps accurate records, showing the exact extent to which the army could be enlarged, should occasion require.

MAUSER CARTRIDGE.
(ACTUAL SIZE.)

MILITARY RIFLES.

THERE are two general classes of rifles now in use in the military service of the United States, viz.: Single loaders and magazine guns. The single loader class are breech-loading guns, which require the insertion of a cartridge by hand into the chamber before firing each shot. The Springfield rifle is a gun of this class. The magazine class are also breech-loading guns and consist of two kinds, viz.:

1. Those which are provided with a device known as the "cut-off," by which the cartridges in the magazine when charged, can be withdrawn from the action of the bolt and which enables the magazine to be held in reserve while the arm is used as a single loader, magazine fire, however, being available at any moment. The United States magazine rifle used by the army is a typical gun of this kind:

2. Those which, when the magazine contains any cartridges, cannot be used as a single loader; arms of this division are, strictly speaking, repeaters. This class of magazine guns is represented by the United States navy rifle.

As the United States volunteers are armed with the Springfield rifle, the regulars with the United States magazine rifle, and the marines and sailors with the United States navy rifle, all three systems will be used during the present war with Spain, and an excellent opportunity for obtaining, under actual service conditions, their relative merits and demerits will be offered.

At the outbreak of the civil war, the Federal troops were armed with muzzle-loading muskets, using the percussion cap. During that war breech-loading arms were used in the military service in this country for the first time, and the urgent necessity of procuring guns wherever they could be obtained resulted in the introduction into the service of many different patterns of arms, requiring a great variety of ammunition. This led to great confusion in obtaining extra parts for making repairs and in supplying the right kind of ammunition to the different regiments.

In this war the army has only two arms, the Springfield rifle and the United States magazine rifle; and as the volunteers have the former and the regulars the latter, no such confusion in supplying ammunition will exist as did during the civil war.

As soon as the civil war was ended, work at once began at the Springfield armory, where all rifles for the army are made, to perfect a breech-loading weapon. After several years' experimenting, a system was perfected and a number of the guns were made and issued to the regular army for practical trial.

The Springfield Rifle.

In 1873 a board of officers, of which Brigadier-General A. H. Terry, United States army, was president, recommended the adoption of the "Springfield" system, after testing in competition 99 different arms of American invention and 9 foreign arms, including the then famous Chassepot, needle-gun and Martini-Henry.

The arm adopted was made and issued to the army and to the militia of the different States; it was known as the Springfield rifle, model 1873. In 1878 a new model of the same system was adopted, which embodied many improvements. In 1888 other changes were embodied in a new model, the principal being the substitution of the

1. NEW UNITED STATES MAGAZINE RIFLE (KRAG-JORGENSEN). 2. SPRINGFIELD RIFLE. 3. NAVY RIFLE (LEE).

knife bayonet for the old triangular. The militia of the States of New York and Massachusetts have recently been equipped with this arm.

Three different models of rear sights were made for the Springfield rifle, viz.: Those of 1873, 1879 and 1884, each being an improvement on and replacing its predecessor. The number of different models through which both the Springfield rifle and its sights have passed, testify to the constant attempt made by the Ordnance Department of the army to produce the best possible arm. Such is the history of the adoption of and the progress made in the manufacture of the Springfield rifle; that of its effectiveness and reliability is best written in the record it has made in the hands of the regular army against the Indians in the West, in the remarkably high proficiency attained in target practice by the regular army as a body, and in the unshaken and profound confidence which every soldier has in that rifle.

This arm was so beloved by the old soldiers of the army that, when it was replaced by the magazine rifle, many parted company with the gun they had used in so many trying places with sad hearts, and looked upon the newcomer as an intruder.

The operation of loading and firing the Springfield rifle is as follows: Raise the hammer to the safety notch, then, with the thumb of the right hand, lift the cam latch until the breech block opens, and swing the latter upward and forward on its hinge until it operates the extractor, which withdraws the empty cartridge case from the chamber. The case is thrown by the extractor to the rear against the ejector, by which it is forced out of the receiver. A cartridge is then inserted in the receiver and forced forward into the chamber by the right hand; the breech block is turned downward to the rear and closed, and the hammer full cocked, when the gun is ready to fire. The rifle, exclusive of the bayonet, is composed of 75 component parts. Thirty-six aimed shots have been fired from this gun in two minutes.

On November 24, 1890, a board of officers was ordered by the War Department to consider and recommend a suitable magazine system for rifles and carbines for the military service, it being deemed imperative that the army should be armed with an "up-to-date" weapon. The members of the board at the date of final report were: Lieut.-Col. R. H. Hall, 6th Infantry: Lieut.-Col. J. P. Farley, Ordnance Department: Major H. B. Freeman, 16th Infantry: Capt. S. E. Blunt, Ordnance Department, recorder: Capt. G. S. Anderson, 6th Cavalry.

Fifty-three different magazine rifles, including the army rifles of all the principal nations of the world, were subjected to a long series of severe tests, and, as the Krag-Jorgensen made the best record, its adoption was recommended by the board on August 19, 1892, which recommendation was approved by the Acting Secretary of War, Mr. L. A. Grant, on September 15, 1892.

The United States Magazine Rifle.

The fact that this arm was of foreign invention produced much dissatisfaction among American inventors, and the board was ordered by the Secretary of War, on March 1, 1893, to reconvene for the purpose of giving American inventors a chance to further perfect their arms, and of having them again tested. Fourteen American guns were tested this time, but not one was found to equal the Krag-Jorgensen.

As soon as this gun was formally adopted, the manufacture of the Springfield rifle was stopped at the Springfield armory, and the installation of the plant for making the new gun was immediately begun. This arm is officially known as the United States magazine rifle.

The first model made was that of 1892; but after two years' experience with the gun in the regular army, and in its manufacture, many improvements were made and are embodied in the model of 1896; in fact, every single component part was improved. The Springfield armory is now making the third model, that of 1898, which embodies still further improvements over that of 1896. These changes show how critically every part of the gun is studied for the purpose of making it as nearly perfect as possible.

NEW UNITED STATES MAGAZINE RIFLE (KRAG-JORGENSEN).

Two model rear sights have so far been made, viz., those of 1892 and 1896, of which the former is no longer in use. The model 1892 allowed no adjustments for elevation to be made except for each 100 yards, while with the model 1896 the elevation can be varied for any range from 275 to 1800 yards; in fact, allowance can be made for even one yard. Neither of these sights, however, permitted adjustment to overcome the drift of the bullet or deflection produced by the wind, and the absence of such feature has been a source of much complaint on the part of the troops, formerly accustomed to the model 1884 sight on the Springfield rifle. This feature was omitted by the War Department because the experience of the civil war proved that a soldier when under fire would seldom, if ever, think of making such fine adjustments with his sight. It was, therefore, decided to make a sight suited for the actual conditions of war, i. e., a war sight, rather than one suited to the conditions obtaining on a target range. This decision is based on sound principles, for if a soldier learns to depend upon adjustments of his sight to enable him to hit the exact point aimed at, and finds himself under conditions that cause him to omit making the adjustments, he is far worse off than if he had learned to use a sight without adjustments, and to allow for the deflection of the bullet by aiming to either side of the target. Which is the better sight for our service is a much debated question, and one which this present war may decide.

The United States magazine rifle is the simplest arm of its kind to take apart, as all of the bolt and magazine mechanisms can be dismounted and again assembled without the use of a single tool.

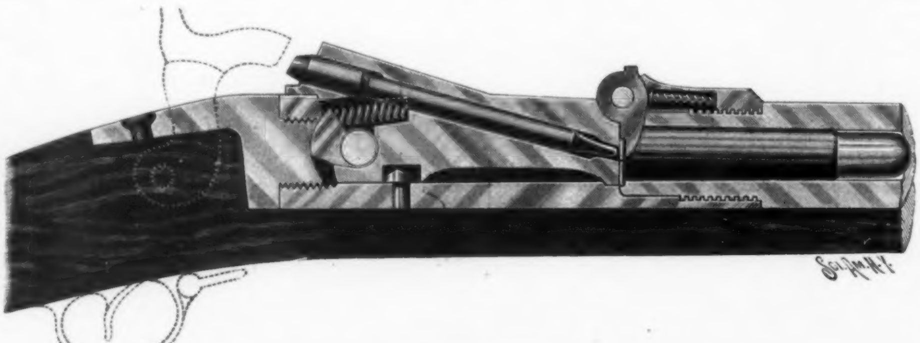
The magazine holds five cartridges, which can be held in reserve by turning the cut-off down; the gun can then be used as a single loader, just as if it had no magazine and, at any moment, the cartridges in the magazine can be fired with wonderful rapidity. Constant firing from the magazine tends to produce carelessness in aiming, as the mind becomes bent on delivering a large number of shots rather than on making each as effective as possible. For this reason the army drill regulations require that the rifle should be habitually used as a single loader, reserving magazine fire for repelling charges or for fighting at close quarters.

To load this arm, the bolt handle is raised and pulled to the rear in one continuous motion, which operation withdraws the empty cartridge case from the chamber and ejects it from the gun. The top cartridge in the magazine then rises in front of the bolt, if using magazine fire, or a cartridge is dropped in front of the bolt by hand, if using single loader fire, and the bolt handle pushed forward and turned down. This motion seats the cartridge in the chamber and cocks the piece, which is then ready to fire.

In a rapid-firing test for accuracy, forty-two shots were fired in two minutes, using the gun as a single loader, and forty-six were fired in the same time, using the gun as a magazine arm. To charge the magazine, the gate is opened and five cartridges inserted from a clip or from the hand; the gate is then closed. The shock of discharge is sustained by the front lug on the bolt, and should this lug yield under excessive pressure, the second lug would then perform the office of the front lug, thus giving double support to the bolt.

The bayonet is of the knife pattern and used not only as a weapon, but for cutting meat and brush, and as an intrenching tool.

There are 85 component parts in this rifle, exclusive of the bayonet. The bullet for this gun has a hard lead core covered with a cupro-nickel-steel jacket.



SPRINGFIELD RIFLE.

The Navy Rifle.

The navy rifle was adopted after a series of tests made by a board of navy officers. The arms tested were all of American invention, and that adopted was the Lee straight-pull rifle.

This gun cannot be used as a single loader when the magazine contains any cartridges, and is virtually a repeating arm. The magazine holds five cartridges, which are packed in a clip by which they are inserted in the magazine. The clips are carried in pockets in the belt and in the blouse.

The most noticeable feature of this gun is the working of the bolt. In opening it, the rear end is raised until the lug, which sustains the shock of discharge, is free from the receiver; the bolt is then

NAVY RIFLE (LEE).

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drawn directly to the rear; in closing the bolt, it is moved forward into position and the rear lowered until the lug engages the recoil shoulder of the receiver. The bolt is manipulated by means of a pivoted handle on which is a lever arm that engages in a projecting recess on the receiver; and this lever arm raises and lowers the rear end of the bolt, so that the motion of opening or closing it is continuous.

In a firing test for rapidity with accuracy, 36 shots were fired in two minutes, using the arm as a single loader, and 55 shots in the same time, using it as a magazine gun.

From a comparison of the above three rifles, it appears that the United States magazine army rifle can be fired more rapidly as a single loader than either of the other two, and that the rapidity of fire of the navy rifle exceeds that of the army when magazine fire is used.

There are 87 components in this rifle, exclusive of the bayonet and sling. The bullet for this gun consists of a hardened lead core, covered with a copper jacket. The bayonet is of the knife pattern, but shorter than that of the army gun.

The following table gives the principal details of the above three arms:

	Springfield Rifle.	U. S. Magazine Rifle.	U. S. Navy Rifle.
Caliber, inches	0·45	0·30	0·236
Length of barrel, inches	32·6	30	28
Weight of gun, without bayonet—pounds	9·3	9·2	8·5
Weight of bullet—grains	500	220	112
Weight of powder charge—grains	70	36 to 40	33·2
Weight of a loaded cartridge—grains	....	440	332
Muzzle velocity	1,310	2,000	2,[illegible]
Extreme range—yards	3,500	4,066	...
Number of seconds required for bullet to travel to extreme range	21·2	34·6	...
Penetration in pine at 100 yards—inches	8·44	11·44	8·1

The accuracy, or the radius of the circle that should contain ten consecutive shots fired by an average marksman for the Springfield and army magazine rifles, is given in the following table:

Range, Yards.	Magazine Rifle. Caliber 30.—Inches.	Springfield Rifle. Caliber 45.—Inches.
100	1·2	1·3
200	2·1	2·7
300	3·3	4·2
400	4·7	5·8
500	6·2	7·6
600	7·7	9·5
700	9·3	11·6
800	11·1	13·8
900	13·0	17·0
1,000	14·9	23·4
1,100	16·8	....
1,200	19·1	....
1,300	21·8	...
1,400	25·0	....
1,500	28·7	....
1,600	35·0	....
1,700	38·0	....
1,800	44·0	....

The accuracy for the Springfield rifle, caliber 45, was not recorded beyond 1,000 yards, although much firing with it was done at all ranges up to 3,500 yards. From this table it is seen that both rifles are about equally accurate up to 500 yards, and that at longer ranges the superiority of the magazine rifle becomes more and more apparent. At 1,300 yards as good a target should be made with the magazine rifle as at 1,000 yards with the Springfield. As all fighting will be done at short ranges in a country having such dense undergrowth as exists in Cuba, the Springfield, from the point of accuracy, is as desirable a rifle as is the magazine for the present war.

The regular army, with the Springfield rifle, ranked first in the world for years for accurate shooting, and with a still more accurate weapon will undoubtedly surpass its former records.

The amount that wind of a certain velocity, blowing perpendicular to the line of fire, will deflect a bullet, depends upon the weight of the bullet, the length of time it is exposed to the action of the wind, and the area of the section of the bullet through its longest axis. In the case of the caliber 45 and caliber 30 bullets, the smaller area, and the shorter time of flight of the latter, more than offset the greater weight of the former. The deflection of the bullets produced by a one mile wind at right angles to the plane of fire is given in the following table for the Springfield and United States army rifles:

Yards.	Magazine rifle. Caliber 30.—Inches.	Springfield rifle. Caliber 45.—Inches.
100	0·6	0·4
200	1·3	1·65
300	2·3	2·5
400	3·5	4·0
500	4·9	5·5
600	5·6	7·5
700	·7	10·0
800	11·1	13·0
900	13·9	17·0
1,000	17·0	22·0
1,100	20·5	....
1,200	24·4	....
1,300	28·8	....
1,400	33·7	....
1,500	39·1	....
1,600	45·0	....
1,700	51·6	...
1,800	58·9	....

Here again the 30 caliber rifle has a slight advantage over the caliber 45 as a target gun. By drift is meant the distance that a bullet deviates to either side of the plane of fire when not influenced by the wind, i. e., when traveling in a dead calm. Drift is due to the rotation of the bullet about its axis, imparted by rifling, during its passage through the bore of the barrel.

A barrel in which the twist of the rifling is right-handed will generally cause the bullet to drift to the right, but in some of the small-caliber rifles the opposite has apparently been found to be the case. After careful investigation, it is now found that when the rifling has a right-handed twist, the drift will be to the right, and vice versa, and that the apparent drift to the left is due probably to a momentary twisting of the barrel during the passage of the bullet through the bore. This yielding of the barrel can be overcome by increasing the area of its cross-section until its strength is great enough to resist the twisting force developed while the bullet is passing through the bore.

The Springfield rifle, when fired in a dead calm, shoots to the right, while the army magazine rifle shoots to the left, as shown by the following table:

Range, Yards.	Caliber 30.—Inches, to the left.	Caliber 45.—Inches, to the right.
100	2·5	1·3
200	3·7	3·0
300	5·1	5·1
400	6·7	7·8
500	8·7	11·5
600	11·1	16·1
700	14·0	21·9
800	17·2	28·4
900	20·7	35·7
1,000	24·0	43·2

Few records of the accuracy, drift and deflection of the bullet by the wind, of the navy rifle, are obtainable, but it is understood that comparative firings made simultaneously with the three arms described herein show that the navy rifle has the greatest penetration up to 300 yards and that at all longer ranges its penetration is less than that of the army magazine rifle;* at ranges greater than 1,000 yards the penetration of the navy bullet is even less than that of the Springfield rifle. When the weights of the three bullets, which are 112 grains for the navy, 220 grains for the army caliber 30, and 500 grains for the caliber 45 Springfield, are considered, this result is what would be expected, for the velocity of the lighter bullet falls off much more rapidly than that of the heavier one. At extreme ranges, the penetration of the caliber 45 bullet is even greater than that of the caliber 30; moreover, the jacket of the navy bullet is copper, and, consequently, it has a far greater tendency to mushroom upon striking than has a steel-jacketed bullet.

The lightness of the navy bullet causes it, at ranges greater than 800 yards, to be much more affected by the wind than is the army caliber 30 bullet.

Both the navy and army magazine rifles use smokeless powder, which in firing produces only a light puff of smoke, or rather vapor, which instantly disappears. That used by the navy is made abroad, while that for the army is all made in this country. The army has used the Peyton, Dupont and Leonard smokeless powders, but of these the first is found most satisfactory and, consequently, is the one most employed.

The rifle is used by the infantry; the cavalry have the carbine, which is the same as the rifle, except that the barrel is 8 inches shorter. The United States magazine carbine is a very handsome arm, well balanced and very accurate. It weighs 8 pounds.

The Spanish troops are armed principally with the Mauser rifle, model 1893. Its caliber is 7 mm. or 0·276; its bullet weighs 173 grains and has a muzzle velocity of 2,286 foot-seconds. The rifle, without the bayonet, weighs 8·7 pounds.

The action of the bolt is similar to that of the United States army rifle. This gun belongs to the repeating class, as it cannot be used as a single loader when the magazine contains any cartridges. These rifles are purchased by Spain from German manufacturers.

The wounds produced by the bullets of the army magazine, the navy, and the Mauser rifles, are peculiar in that at short and very long ranges an explosive effect is produced, while at mid ranges a clean hole is made. The opportunities for fully determining the effectiveness of the small caliber bullets having high velocities have been few, and some complaint is heard that they do not stop a strong man unless he is struck in a vital spot. There can be no question of the stopping power of the caliber 45 bullet. This is a subject that the army and navy surgeons can be relied upon to settle definitely during the present war, if opportunity is afforded.

THE WORLD'S PROGRESS IN THE MANUFACTURE OF ORDNANCE.

THE accompanying tables of our own ordnance and that of the leading manufacturers of the world are introduced to show the general direction in which the design of heavy ordnance is tending at the present time. Comparing the guns of Elswick, Krupp and Schneider-Canet with our own, one is struck with the great length and high velocities of the foreign guns, especially those of Schneider-Canet, which have in some cases the abnormal length of 80 calibers and velocities running as high as 3,281 feet per second.

These features are due to the introduction of smokeless powder, which on account of its slow-burning qualities requires a great length of bore to develop its full ballistic properties. In our article on this subject it was pointed out that the early guns were short, and very thick at the breech, possessing a form which was determined by the quick-burning qualities of the powder employed. The instantaneous conversion of the charge into gas at the moment of firing produced extreme pressure at the breech and called for great strength at that part of the gun. The introduction of the smokeless powders, with their capacity for being converted slowly into gas, made it unnecessary to provide so heavy a breech, but desirable to prolong the bore of the gun. If smokeless slow-burning powder is burned in a gun of shorter length than that for which it is designed, a large part of it will not have time to be consumed before it reaches the muzzle, and will pass from the gun in the solid state.

The limit of useful, or at least of unobjectionable, length is probably reached at 50 calibers for the rapid-fire guns of medium caliber, and at 45 calibers for the heavy rifles. Elswick, Vickers and Krupp do not build guns whose bore is over fifty times the diameter in length; and only Canet, who has always been an advocate of great length, goes beyond this, turning out a 6·3-inch gun up to 60 calibers, and a 4·7-inch gun up to 80 calibers in length. These guns would be a positive nuisance on shipboard, and they are presumably intended for service only in fixed fortifications.

Our own guns, it will be observed, are invariably shorter, and show lower velocities and energies than the foreign guns. This is not to be taken as evidence that they are inferior weapons; for it is a generally conceded fact that in respect of durability and excellence of workmanship our army and navy weapons are equal to any produced in other countries. The differences in length and ballistic results are due solely to the fact that our guns were designed for the use of the brown powder, and the dimensions of powder chambers and lengths of bores were determined accordingly. As

UNITED STATES NAVAL ORDNANCE.

NATURE OF GUN.	Calibre	Weight.	Total Length.	Weight of Service-charge (not Smokeless Powder.)	Weight of Projectile.	Muzzle Velocity (Service).	Muzzle Energy.	Perforation of Wrought Iron at Muzzle.†
						Brown Powder.		
	inch.	tons.	feet.	lbs.	lbs.	ft.-seconds.	ft.-tons.	inch.
4-in. Q.-F., Mark I.	4	1·5	13·7	12 to 14	33	2000	915	9·8
4-in. Q. F. Gun	4	1·5	13·7	..	33	2000	..	9·8
5-in. Q.-F., Mark I.	5	2·8	13·5	26 to 29	60	2080	1,660	11·8
5-in. Q.-F. Gun	5	3·1	17·4	28 to 30	50	2300	1,834	13·2
6-in. B.L.R., Mark I.	6	4·8	15·8	50	100	2000	2,773	..
6-in. B.L.R., Mark II.	6	4·9	16·1	45 to 48	100	2000	..	13·8
6-in. B.L.R., Mark III., of 30 Cals.	6	4·8	16·3	44 to 47	100	2000	..	..
6-in. B.L.R., Mark III., of 35 Cals.	6	5·2	18·8	..	100	2060	2,990	14·7
6-in. B.L.R., Mark III., of 40 Cals.	6	6·0	21·3	..	100	2150	3,204	15·4
6-in. Q.-F. Gun	6	6·0	21·3	44 to 47	100	2150	3,200	15·4
8-in. B.L.R., Mark I.	8	12·3 / 12·9	21·5	105 to 115	250	2000	6,932	19·0
8-in. B.L.R., Mark II.	8	13·0	21·5	...	250	2000		19·0
8-in. B.L.R., Mark III., of 35 Cals.	8	13·1	25·4	..	250	2080	7,498	20·1
8-in. B.L.R., Mark III., of 40 Cals.	8	15·2	28·7	..	250	2150	8,011	21·1
10-in. B.L.R., Mark I., of 30 Cals.	10	25·7	27·4	225 to 240	500	2000	13,864	24·0
10-in. B.L.R., Mark I., of 35 Cals.	10	27·1 / 28·2	30·5	..	500	2060	14,760	25·0
10-in. B.L.R., Mark II., of 30 Cals.	10	25·1	27·4	..	500	2000	13,864	24·0
10-in. B.L.R., Mark II., of 35 Cals.	10	27·6	31·2	..	500	2100	15,285	25·8
12-in. B.L.R., Mark I.	12	45·2	36·8	425	850	2100	25,985	30·8
13-in. B.L.R., Mark I.	13	60·5	40·0	550	1100	2100	33,627	33·8

* For the tables of guns we are indebted to Bruff's Ordnance and Gunnery and Brassey's Naval Annual.

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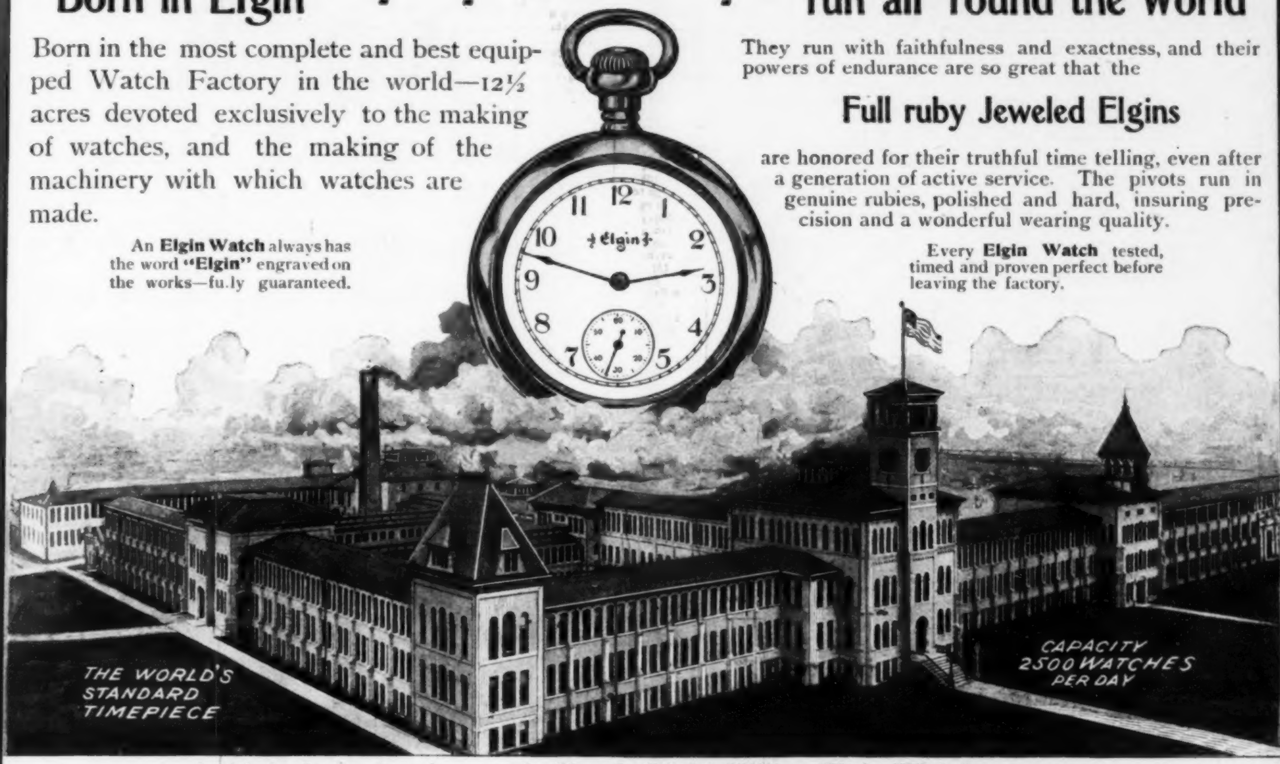

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PRINCIPAL DIMENSIONS, WEIGHTS, ETC., OF FIELD AND SIEGE ARTILLERY.

TABLE I.—BREECH-LOADING ORDNANCE, U. S. LAND SERVICE

[Guns, howitzers, and mortars of 3 inches calibre and upwards.]

	Hotchkiss Mountain-gun, Steel.	Field-artillery, Steel.			Siege-artillery, Steel.		
		Light Gun, model 1890.	Heavy Gun, model 1891.	Mortar, model 1890.	Gun, model 1890.	Howitzer, model 1890.	Mortar, model 1892.
Calibre, inches	3	3.2	3.6	3.6	5	7	7
Weight: Pounds	218	805	1,181	244	3,660	3,710	1,715
Tons							
Total length, feet	3.76	7.31	7.79	2.05	12.15	8.475	4.86
Length of bore, calibres	13.48	25.20	23.50	5.19	27	12.67	7
Diameter over powder chamber, inches	6.7	9.00	9.80	7.80	15.0	16.70	13.80
Diameter of powder-chamber, inches	3.15 to 3.21	3.60	3.90	3.80	5.7	7.20	7.25
Thickness over powder-chamber, calibres	0.55	0.75	0.76	0.48	0.82	0.66	0.45
Number of cylinders comprised in the thickness	1	2	2	1	2	2	1
Maximum tangential resistance, pounds per sq. in.	23,850	38,080	39,160	22,050	37,520	35,120	22,000
Rifling: Number of grooves	24	24	26	20	30	42	28
Width of grooves, inches	0.276	0.3	0.3162	0.4454	0.3736	0.3736	0.6354
Depth of grooves, inches	0.026	0.04	0.04	0.045	0.05	0.05	0.055
Width of lands, inches	0.117	0.1188	0.1188	0.12	0.15	0.15	0.15
Twist, calibres	1 in 25.59 uniform	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 40 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 40 to 1 in 15
Total capacity of bore, cubic inches	292	689.3	894.5	200.2	2,824.5	3,320.1	1,950.9
Capacity of powder-chamber, cubic inches	27.12	110.3	149.2	33.2	395.6	315.7	182.8
Length of powder-chamber, inches	3.72	10.7	12.275	2.835	15.15	7.465	4.28
Travel of projectile in bore, calibres	12.243	21.81	20.08	4.47	23.96	11.61	6.40
Powder-charge: Kind	(a)	(b)	(b)	(b)	(b)	(a)	(c)
Weight, pounds	0.875	3.5	4.1875	15 ozs.	12.5	10	5.5
Density of loading	0.9	0.8780	0.777	0.833	0.875	0.877	0.833
Projectile: Weight, pounds	12	13.5	20	20	45	105	125
Ratio to weight of piece	1 to 19	1 to 60	1 to 59	1 to 12	1 to 81	1 to 35	1 to 13
Pressure in powder-chamber, pounds per square inch	14,560	35,000	35,000	16,000	35,840	28,224	18,000
Muzzle velocity, feet-seconds	890	1,685	1,550	650	1,830	1,085	690
Muzzle energy, foot-tons	63	266	333	59	1,045	857	412
Penetration of steel: Muzzle, inches	1.4	3.8	3.9	1.1	6.2	3.8	2.2
3500 yards, inches	...	...	...	...	2.5	2.4	...

a I. K. granular. b U. F. sphero-hexagonal. c I. B. sphero-hexagonal.

TABLE II.—BREECH-LOADING ORDNANCE, U. S. LAND SERVICE.

	Seacoast Guns, Steel.					Seacoast Mortars.	
	Model 1888, M.	Model 1888, M.	Model 1888, M.	Model 1892.	Proposed.	Cast iron Steel-hooped.	Steel.
Calibre, inches	8	10	12	12	16	12	12
Weight: Pounds	32,372 / 32,480	67,200	116,480	128,719	280,000	31,920	29,120
Tons	14.5	30	52	57.5	125	14.25	13
Total length, feet	23.21	30.60	36.66	40.0	49.67	10.75	11.76
Length of bore, calibres	32	34	34	37.83	35	9	10
Diameter over powder-chamber, inches	30	38.5	46.2	46.4	62	41.75	38
Diameter of powder-chamber, inches	9.5	11.8	14.8	14.5	18.8	12.4	12.5
Thickness over powder-chamber, calibres	1.08	1.13	1.125	1.10	1.148	1.18	1.02
Number of cylinders comprised in the thickness	3	4	4	4	4	3	3
Maximum tangential resistance, pounds per sq. in.	51,980	53,090	53,000	52,640	53,000	29,490	50,200
Rifling: Number of grooves	48	60	72	72.0	96	68	72
Width of grooves, inches	0.3736	0.3736	0.3736	0.3736	0.3736	0.379	0.3736
Depth of grooves, inches	0.06	0.06	0.06	0.06	0.07	0.07	0.06
Width of lands, inches	0.15	0.15	0.15	0.15	0.15	0.175	0.15
Twist, calibres	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 40 to 1 in 25	1 in 40 to 1 in 20
Total capacity of bore, cubic inches	14,125	28,977	50,049	55,829	121,487	12,554	13,947
Capacity of powder-chamber, cubic inches	3,597	7,064	12,092	12,798	29,341	1,990	2,636
Length of powder-chamber, inches	50.75	65.09	77.33	78.58	106.06	15.75	20.8
Travel of projectile in bore, calibres	25.66	27.51	27.58	31.09	28.37	7.66	8.225
Powder charge: Kind	(a)	(b)	(c)	(d)	(d)	(e)	(e)
Weight, pounds	125	250	490	487	1,060	80	105
Density of loading	0.9619	0.9797	1.0085	1.0535	1	1.1128	1.1026
Projectile: Weight, pounds	300	575	1,000	1,000	2,370	800 / 1,000	800 / 1,000
Ratio to weight of piece	1 to 108	1 to 117	1 to 116	1 to 129	1 to 118	1 to 40	1 to 36
Pressure in powder-chamber, lbs. per square inch	37,000	37,000	37,000	38,000	37,000	27,500	30,000
Muzzle velocity, ft.-secs.	1,950	1,975	1,975	2,100	1,975	1,020	1,140
Muzzle energy, foot-tons	7,907	15,548	27,042	30,570	64,084	5,770	7,207
Penetration in steel: Muzzle, inches	16.0	20.4	24.9	27.1	33.8	8.2	9.7
3500 yards, inches	10.6	14.6	18.7	20.6	27.5	...	...

a U.R. brown prismatic. b W.H. brown prismatic. c V.P. brown prismatic. d brown prismatic; e V.M. brown prismatic.

COMPARATIVE TABLE OF 12-INCH GUNS.

12-inch guns.	Weight in tons.	Length in feet.	Length of bore in calibers.	Weight of powder charge in pounds.	Weight of projectile in pounds	Muzzle velocity in ft. per sec.	Muzzle energy in foot-tons.	Penetration at muzzle, iron.
United States army gun, hooped	57·5	40	37·8	487 brown.	1,000	2,100	30,570	34·7
United States navy gun, hooped	45·2	36·8	35	425 brown.	850	2,100	25,985	30·8
English navy gun, wire-wound	46	37·1	35·4	167½ cordite.	850	2,367	33,020	36·8
French navy gun, hooped	45·9	42	40	198·4 smokeless	643·8	2,625	30,750	....
Vickers Sons and Maxim, wire-wound, English	50·3	41·4	40	207 cordite.	850	2,750	44,573	45·0
Brown segmental, wire-wound, American	48	47	45	?	850	3,000	48,000	48·8

53,032

the maximum pressure of the smokeless powder is about the same as that of the brown powder, the former could be used in our guns, although their relatively short length of 30 to 40 calibers would not permit us to obtain the high velocities which are given by the 40 to 50-caliber guns of foreign makers. Of course, the short length might be compensated for by using the stronger smokeless powders with a high percentage of nitroglycerine; but our ordnance officers have but little faith in the stability of these powders (of which ballistite and cordite are the best known), and prefer to use for the navy an all-guncotton powder, and for the army a powder containing not more than about 25 per cent of nitroglycerine.

There is not the least doubt that smokeless powder has come to stay. That being the case, we ought to build our guns to match the powder, giving them the greater length and modified powder chamber necessary to develop the full potentiality of the new explosives. We draw particular attention to the comparative table of 12-inch guns and the enormous energies developed by the Vickers and Brown weapons of the wire-wound type. Our ordnance experts claim that by the use of nickel-steel they can equal these results in a gun of the hooped or built-up type. If they can, it is to be hoped that such a gun will quickly be built and sent to the proving ground; but whether our future guns are to be hooped or wire-wound, we do sincerely hope that the next models of navy and army guns that we build will have their energies raised from the 26,000 and 30,000 foot-tons energy of the present patterns up to the 45,000 and 48,000 foot-tons energy of the Vickers and Brown types.

THE SEA-GOING BATTLESHIP IOWA."

IN our introductory chapter we spoke of the necessity for placing the outposts of a country's defences at the enemy's seaboard, and referred to that splendid ship, the "Iowa," as the type of vessel which is specially designed for service at great distances from home waters.

We present with our present issue a double-page engraving of the "Iowa," which we venture to claim, with all modesty, is the finest representation of the battleship that has yet appeared. In her great coal capacity, her size, lofty freeboard and general roominess, and her great offensive power, she embodies all the requisites for carrying the strife into any corner of

VICKERS, SONS, AND MAXIM GUNS.

Type of Gun	Diameter of Bore.	Length of Bore.	Total Length of Gun.	Diameter of Chamber.	Length of Chamber.	Maximum Pressure in Chamber.	Weight of Charge.	Weight of Projectile.	Total Weight of Gun, including Breech Mechanism.	Muzzle Velocity in Feet per Second.	Muzzle Energy in Foot Tons.	Penetration of Wrought Iron Plate at Muzzle by Gavre's Formula.	Penetration of Steel Plate at Muzzle by Gavre's Formula.	Rounds per Minute.
	in.	in.	in.			tons	lb. oz. gr.	lb.	tons cwt. qrs. lb			in.		
37 mm. 30 cal.	1.457	43.5	73.75	1.44	2.06	13	0 1 110	1.0	0 4 0 22	1800	22.5	1.9	1.5	300
37 mm. 42.5 cal.	1.457	62.0	94.0	1.6	2.78	14	0 3 0	1.25	0 5 1 26	2200	46	3.3	2.8	300
47 mm. 40 cal.	1.85	73.72	77.95	2.06	12.08	13	0 9 0	3.3	0 4 0 0	2125	103	4.5	3.5	30
47 mm. 47.2 cal.	1.85	87.31	91.5	2.06	12.93	13	0 11 0	3.3	0 4 2 0	2400	132	5.3	4.1	30
57 mm. 42.3 cal.	2.244	95.0	104.4	2.45	10.2	15	0 15 0	6.0	0 8 2 0	2300	220	6.1	4.8	24
57 mm. 50 cal.	2.244	112.2	118.4	2.8	14.2	16	1 4 0	6.0	0 8 0 0	2500	260	7	5.4	20
Naval 76.2 mm. 45 cal.	3.0	135.0	138.0	3.5	18.0	16	2 9 0	12.5	0 16 2 16	2550	566	9.2	7.1	20
Naval 76.2 mm. 50 cal.	3.0	150.0	153.0	3.5	19.0	16	2 9 0	12.5	0 15 3 0	2700	632	9.7	7.5	20
Field 76.2 mm. 23.5 cal.	3.0	70.5	75.15	3.4	9.6	14	1 0 0	12.5	0 5 2 22	1700	250.4	...	...	20
Mountain 75 mm. 10.7 cal.	2.953	31.6	35.85	3.0	4.575	5	0 6 110	12.5	0 2 0 13	905	73	...	...	16
101.6 mm. 45 cal.	4.0	180.0	186.1	5.0	21.2	17	6 0 0	25.0	1 13 0 0	2700	1,263	11.6	9.0	15
101.6 mm. 50 cal.	4.0	200.0	206.0	5.0	21.2	17	6 0 0	25.0	1 16 0 0	2800	1,350	12.3	9.5	15
12 cm. 40 cal.	4.724	188.96	193.25	6.1	25.5	16	8 8 0	45.0	2 10 0 0	2494	1,960	13.4	10.3	12
12 cm. 45 cal.	4.724	212.58	217.0	6.6	25.75	17	9 0 0	45.0	2 14 0 0	2600	2,100	14.1	10.9	12
15.24 cm. 40 cal.	6.0	240.0	249.2	6.8	32.5	16	19 0 0	100.0	6 15 0 0	2530	4,437	18.6	14.4	8
15.24 cm. 45 cal.	6.0	270.0	279.2	8.5	32.0	17	25 0 0	100.0	7 8 0 0	2775	5,340	21.1	18.4	8
20.3 cm.† 45 cal.	8.0	360.0	371.7	10.0	45.0	17	55 0 0	210.0	16 18 3 0	2750	11,018	28.0	20.2	5
23.36 cm.† 45 cal.	9.2	414.0	478.8	12.5	67.0	17	86 0 0	380.0	26 16 0 0	2730	19,627	34.3	26.6	...
25.4 cm.† 42 cal.	10.0	425.15	450.0	11.5	65.50	17	100 0 0	400.0	30 4 0 0	2680	20,811	32.2	25.0	...
30.48 cm.† 40 cal.	12.0	480.0	496.5	17.5	87.2	17	207 0 0	850.0	50 7 0 0	2750	44,573	45.9	35.5	...

† Now under construction.

All these guns use smokeless powder.

ELSWICK QUICK-FIRING GUNS.

This Table is supplied by the Manufacturers. The entire Table refers to existing guns.

	Automatic Machine gun											Field and Naval																	
Diameter of Bore, ins.	1·46	1·46	1·46	1·46	1·65	1·85	1·85	2·244	2·244	2·244	2·244	3·0	3·0	3·5	4		4		4·7	4·7	4·7	6	6	6	6	† 8		† 8	
do. do. mm.	Maxim-Nordenfelt 37	Hotchkiss 37	Hotchkiss 37	37	Maxim-Nordenfelt 42	Hotchkiss 47	Maxim-Nordenfelt 47	Maxim-Nordenfelt 57	Maxim-Nordenfelt 57	Hotchkiss 57	Hotchkiss 57	76·2	76·2	88·9	100		100		120	120	120	152	152	152	152	203		203	
Length of Bore, cals.	29·9	20	25	45	41·75	40	45·4	42·3	43·5	40	50	28	40	40	40		48·7		40	43·9	48·9	40	40	45	50	40		44·6	
do. Gun, do.	..	22·7	27·8	46·7	46·2	43·6	..	..	..	43·6	53·6	29·2	41·2	41·3	41·3		50		41·1	45	50	41·54	41·54	46·54	51·54	41·63		46·3	
Weight of Gun	lbs. 456	lbs. 73	lbs. 79	lbs. 268	lbs. 379	lbs. 506	lbs. 532	lbs. 700	lbs. 756	lbs. 800	cwts. 10	cwts. 7·5	cwts. 12·0	cwts. 24	cwts. 32		cwts. 36		cwts. 42	cwts. 53	cwts. 55	tons 5·8	tons 6·6	tons 7	tons 7·6	tons 15·5		tons 19·9	
do. Projectile, lbs.	1·0	1·1	1·1	1·5	2·5	3·3	3·3	6	6	6	6	12·5	12·5	20	25	30	25	30	45	45	45	100	100	100	100	210	250	210	250
do. Charge, lbs.	1·96	1·25	1·25	4·5	..	6·8	9·5	12·5	1·0	7·75	..	13·5	1·62	3·75	5	5	5	5	5·5	8·4	8·4	15	19·5	19·5	19·5a	32	32	46	46
Muzzle Velocity, f.-s.	1800	1319	1460	2300	2010	2002	2300	2300	2400	1940	2592	1585	2200	2420	2540	2325	2650	2430	2150	2570	2630	2220	2500	2570	2642	2242	2068	2650	2480
Velocity at 2,500 Yards, f.-s.	600	570	595	732	896	903	966	1060	1094	966	1172	904	1084	1256	1251	1351	1386	1412	1275	1518	1564	1517	1706	1756	1506	1626	1582	1918	1886
Muzzle Energy, f.-t.	22·5	13·3	18·3	55·0	70·0	91·7	121·0	220	240	156·6	279·5	217·8	419·5	812·2	1118	1124	1217	1228	1442	2061	2158	3417	4334	4580	4840	7319	7413	10226	10662
Energy at 2,500 Yards, f.-t.	..	..	..	..	13·9	18·7	21·3	46·7	49·8	38·8	57·2	70·8	102	219	271	380	333	415	507	719	763	1596	2018	2138	2262	3850	4339	5357	6166
Penetration at Muzzle ‡ ins.	2·4	1·5	1·8	3·5	4·2	4·5	5·6	6·9	7·3	5·3	8·2	4·9	8·0	10·6	12·1	11·5	12·9	12·2	12·1	15·9	16·4	16·2	19·4	20·2	21·0	20·3	21·0	26·4	26·4
Rounds per Minute	250	..	..	25	32	30	30	28	28	25	25	20	20	15	15	15	15	15	10	10	10	7	7	7	7	4	3	4	3

† No cartridge case used.

‡ Worked out by compiler, on Tresidder's formula. § Velocities of 2813 and 2600 f.s. are obtained with the 210 and 250 lb. projectiles, respectively, with Battering charges.

a With special charges and suitable cordite a velocity of 2940 f.s. has been obtained with 100 lb. projectiles. This high velocity, however, is not desirable, except on very rare occasions, on account of the excessive wear of the gun.

SOME RESULTS ACTUALLY OBTAINED.

4·7-inch 42 cwt. gun, with single motion breech mechanism, 5 rounds in 22 seconds, at Silloth, at a target, 2 hits, range 1,000 yards; 7 rounds in 25 seconds at drill.

6-inch Admiralty gun, with three-motion breech mechanism, and E.X.E. powder, 10 rounds in 85 seconds, at sea, on board gunboat *Kite*; 18 rounds in 3 minutes, H.M.S. *Royal Arthur*, 14 hits on target, ship steaming 8 knots, range from 1,600 to 2,200 yards; *18 rounds in 3 minutes, H.M.S. *Blake*, 15 hits on target, ship steaming 8 knots, range from 1,600 to 2,200 yards.

* Total number of rounds fired from 10 guns in same time 148, of which 118 hit the target.

6-inch 6·6-ton gun, with single motion breech mechanism, 7 rounds in 61 seconds, at Silloth, cordite charge; 4 rounds in 20 seconds, at drill.

8-inch 15·5-ton gun, with single motion breech mechanism, 3 rounds in 28 seconds, at drill; 4 rounds in 62 seconds, on board cruiser *Blanco Encalada*, ammunition supplied from magazine.

13·5-inch 68-ton B.L. gun, with hydraulic breech mechanism, 7 rounds in 12 minutes, H.M.S. *Royal Sovereign*, 6 hits on target, ship steaming 8 knots, range from 1,600 to 2,200 yards; 4 rounds in 6 minutes, H.M.S. *Empress of India*, with an interval between rounds of only 1 minute 27 seconds.

12-inch 46-ton B.L. gun, interval between 2 rounds, 1 minute 19 seconds, H.M.S. *Majestic*; 1 minute 4 seconds, H.M.S. *Cæsar*.

NOTE.—Although special arrangements and automatic gear are applied to heavy pieces, including the 12-in. gun, the projectiles are too heavy for rapid handling, and no piece exceeding 8 inches calibre is classed under the category of Q.-F. guns at Elswick.

the high seas, and fighting it out with the enemy in any wind or weather.

It was our intention to have given a detailed description of this vessel; but limitations of space forbid and a few leading particulars must suffice. As compared with the "Oregon," which is known as a coast-defence battleship, the "Iowa" is 12 feet longer, has 3 feet more beam, the same draught, and about 1,000 tons greater displacement. Her superior sea-going qualities are due to her higher freeboard, a raised spar deck extending from the bow two-thirds of the way aft, and raising her freeboard 8 feet higher than that of the "Oregon," the height being respectively 12 and 20 feet. The forward guns are thus carried at a level of about 26 feet above the water line, and unlike those of the coast-defence battleships can be fought in a heavy head sea. Another sea-going feature is the large coal supply of 1,795 tons, sufficient to carry the "Iowa" across the Atlantic and back without recoaling.

In speed, moreover, the sea-going vessel is the fastest of our first-class battleships. On her trial trip, when fresh from the yard of her builders, Wm. Cramp & Sons, she averaged 17·1 knots over a 66-knot course. Her armor is lighter than that on the "Oregon;" but being of later type, and embodying all the advantages conferred by nickel-steel and reforging, it has equal resistance to penetration. The "Iowa" has already taken a very active part in the operations of the war, and her 12-inch rifles have left their mark upon the Spanish fortifications at San Juan and Santiago. Should the government persist in its determination to send a flying squadron to Spanish waters, the "Iowa" will be the most formidable vessel of the expedition.

SCHNEIDER-CANET QUICK-FIRE GUNS. Model 1898.

Existing guns, or guns which differ very little from such as have been constructed, are denoted by an asterisk.

This Table is supplied by the Manufacturers.

Calibre, in centimètres	24			21			16			* 15			14			12			
Calibre, in inches	9·45			8·27			6·30			5·91			5·51			4·72			
Length, in calibres	40	45	50	40	45	50	* 45	50	60	* 45	50	60	* 45	50	60	* 45	* 50	60	80
Length, in feet	31·5	35·4	39·4	27·6	31·0	34·4	23·6	26·2	31·5	22·2	24·6	29·5	20·7	23·0	27·6	17·7	19·7	23·6	31·5
Weight of Gun, in tons	20·7	22·5	26·1	13·9	15·1	17·5	7·28	7·73	8·56	5·71	6·10	7·09	4·82	5·17	5·76	2·85	3·15	3·64	6·15
Weight of Projectile, in lbs.	330·7			242·5			101·4			88·2			70·5			46·3			
Muzzle Velocity, in ft.-secs.	2493	2625	2756	2493	2625	2756	2625	2756	2953	2625	2756	2953	2625	2756	2953	2625	2756	2953	3281
Velocity at 2000 mètres, in ft.-secs.	1969	2074	2182	1900	2001	2106	1867	1956	2103	1860	1955	2093	1818	1913	2047	1719	1811	1939	2152
Muzzle Energy, in ft.-tons	14258	15799	17418	9506	10533	11621	4846	5341	6132	4211	4645	5332	3371	3716	4265	2212	2439	2799	3455
Energy at 2000 mètres, in ft.-tons	8887	9860	10917	5517	6141	6783	2451	2716	3111	2116	2339	2679	1616	1790	2051	949	1054	1204	1487
Perforation at muzzle, in ins.†	30·3	33·8	35·4	26·0	28·1	30·2	21·1	22·8	25·3	20·4	22·0	24·5	18·7	20·1	22·3	16·1	17·4	19·3	22·6
" " " ‡	27·9	30·0	32·3	25·5	27·5	29·7	20·5	22·2	24·5	19·7	21·2	23·6	18·2	19·5	21·3	15·9	17·1	19·1	22·4
Perforation at 2000 mètres, in ins.†	21·1	22·8	24·7	17·4	18·5	20·0	12·5	13·5	15·0	12·0	13·0	14·2	10·6	11·5	12·7	8·4	9·1	10·1	11·9

Calibre, in centimètres	10				9			75 mm.			* 65			57			47			37		
Calibre, in inches	3·94				3·50			3·03			2·57			2·24			1·85			1·46		
Length, in calibres	* 45	* 50	* 60	* 80	50	60	80	* 50	60	80	* 60	70	80	* 60	70	* 80	50	60	70	50	60	70
Length, in feet	14·8	16·4	19·7	26·2	14·8	17·7	23·6	12·3	14·8	19·7	12·8	14·9	17·1	11·2	13·1	15·0	..	..	..	..	..	..
Weight of Gun, in tons	1·77	1·89	2·12	3·54	1·38	1·57	2·56	0·79	0·89	1·53	0·64	0·79	0·94	0·50	0·69	0·79	0·24	0·27	0·33	0·13	0·15	0·18
Weight of Projectile, in lbs.	28·7				22·0			13·2			8·82			6·0			3·3			1·8		
Muzzle Velocity, in ft.-secs.	2625	2723	2920	3215	2690	2887	3182	2658	2854	3150	2658	2854	3150	2625	2822	3117	2329	2550	2723	2297	2493	2690
Velocity at 2000 mètres, in ft.-secs.	1640	1703	1831	2011	1640	1755	1939	1496	1668	1775	1394	1496	1650	1033	1083	1171	1017	1086	1129	945	984	1017
Muzzle Energy, in ft.-tons	1369	1474	1696	2055	1107	1275	1549	648	748	910	432	498	607	284	329	401	111	150	178	64	76	88
Energy at 2000 mètres, in ft.-tons	525	576	666	804	411	471	574	205	237	289	119	137	167	44	48	57	24	27	29	11	12	13
Perforation at muzzle, in ins.†	13·7	14·9	16·1	18·7	13·2	14·7	17·1	10·8	12·0	14·0	9·3	10·4	12·1	7·8	8·8	10·2	5·2	5·5	5·7	4·1	4·7	5·3
" " " ‡	13·7	14·5	16·1	18·6	13·4	14·8	17·3	10·9	12·2	14·0	9·6	10·7	12·4	8·3	9·3	10·8	5·7	6·6	7·2	4·6	5·2	5·9
Perforation at 2000 mètres, in ins.†	6·7	7·0	7·9	9·1	5·7	6·8	8·0	4·4	5·0	5·8	3·4	3·9	4·4	1·9	2·0	2·3	1·5	1·6	1·7	1·1	1·1	1·2

† Through wrought iron, apparently calculated by De Marre's formula. ‡ Through wrought iron, by Tresidder's formula.

The compiler is responsible for the conversion of figures supplied into British units, and for the calculation of the perforations through wrought iron on Krupp's system.

KRUPP QUICK-FIRE GUNS.

Quick-Fire Guns of 40 and 50 calibres in length.

This Table is supplied by Manufacturers, who have indicated existing service-guns with an asterisk.

Calibre, in centimètres	4		4·7		5		5·3		5·7		6		7		7·5		8		8·4		8·7	
Calibre, in inches	* 1·57		* 1·85		* 1·97 *		* 2·09		* 2·24		* 2·36 *		* 2·76		* 2·95		3·15 *		* 3·31		* 3·43 *	
Total Length, in feet	5·25	6·56	6·17	7·71	6·56	8·29	6·95	8·69	7·48	9·35	7·87	9·84	9·19	11·48	9·84	12·30	10·50	13·12	11·02	13·78	11·42	14·27
Length of Bore, in inches	56·9	72·6	67·5	86·0	72·0	91·7	76·4	97·2	82·1	104·5	86·6	110·2	100·8	128·4	108·3	137·8	115·8	147·2	121·9	154·9	126·4	160·6
Length of Gun, in calibres	40	50	40	50	40	50	40	50	40	50	40	50	40	50	40	50	40	50	40	50	40	50
Weight of Piece, in lbs.	216·1	238·1	352·7	388·0	423·3	467·4	504·9	555·6	628·3	692·2	731·9	806·9	1164·0	1280·9	1430·8	1576·3	1719·6	1913·6	2010·6	2215·6	2233·3	2460·3
Weight of Piece, in tons	..	..	..	..	..	..	..	..	0·28	0·31	0·33	0·36	0·52	0·57	0·64	0·70	0·77	0·85	0·90	0·98	1·00	1·10
Weight of Steel Projectile, in lbs.	1·94		3·33		3·97		4·50		5·60		6·53		10·30		12·74		15·45		17·90		19·89	
Weight of Charge, in lbs.	0·33		0·57		0·68		0·81		1·01		1·18		1·87		2·30		2·79		3·23		3·59	
Muzzle Velocity, in ft.-secs.	2379	2493	2379	2493	2379	2493	2379	2493	2379	2493	2379	2493	2379	2493	2379	2493	2379	2493	2379	2493	2379	2493
Muzzle Energy, in foot tons	76	83	123	135	148	163	177	194	219	241	256	281	406	447	500	549	606	666	702	771	780	857
Perforation through Steel,† in ins.	3·31	3·54	3·90	4·17	4·17	4·45	4·49	4·76	4·80	5·12	5·08	5·43	5·98	6·42	6·46	6·89	7·05	7·40	7·28	7·80	7·64	8·11

Calibre, in centimètres	9		10·5		12		13		14		15		16		21		24	
Calibre, in inches	3·54		* 4·13		* 4·72		5·12		5·51		* 5·87 *		6·30		8·24		9.45	
Total Length, in feet	11·81	14·76	13·78	17·22	15·73	19·69	17·06	21·33	18·37	22·97	19·55	24·61	21·00	26·25	* 27·56	34·45	* 31·50	39·37
Length of Bore, in inches	131·1	166·5	153·6	194·9	176·4	223·7	190·2	241·4	205·4	260·5	218·4	279·0	234·5	297·5	307·5	390·2	350·4	444·9
Length of Gun, in calibres	40	50	40	50	40	50	40	50	40	50	40	50	40	50	40	50	40	50
Weight of Piece, in lbs.	2173·6	2724·9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Weight of Piece, in tons	1·10	1·22	1·64	1·87	2·35	2·69	3·12	3·54	3·88	4·41	4·70	5·35	5·88	6·60	16·24	20·18	25·40	31·50
Weight of Steel Projectile, in lbs.	22·05		30·9		44·1		58·4		72·8		88·2		110·2		238·1–308·7	238·1–308·7	352·7–474·0	352·7–474·0
Weight of Charge, in lbs.	3·98		6·83		9·70		12·34		15·13		18·52		23·15		57·32	57·32	85·98	85·98
Muzzle Velocity, in ft.-secs.	2379	2493	2461	2625	2461	2625	2461	2625	2461	2625	2461	2625	2461	2625	2625–2297	2822–2461	2625–2297	2822–2461
Muzzle Energy, in foot-tons	865	950	1296	1475	1851	2107	2453	2791	3055	3476	3703	4213	4628	5266	11376–11293	13146–12962	16853–17340	19478–19905
Perforation through Steel,† in ins.	7·87	8·43	8·90	9·76	9·96	10·91	11·14	12·24	12·05	13·19	12·95	14·17	14·06	15·39	20·08–19·84	22·25–22·01	22·95–23·35	25·39–25·79

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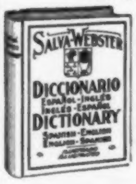

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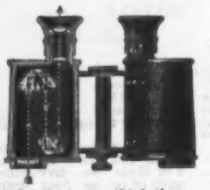

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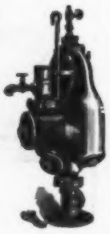

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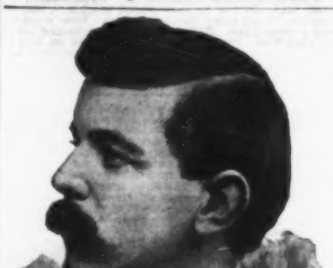

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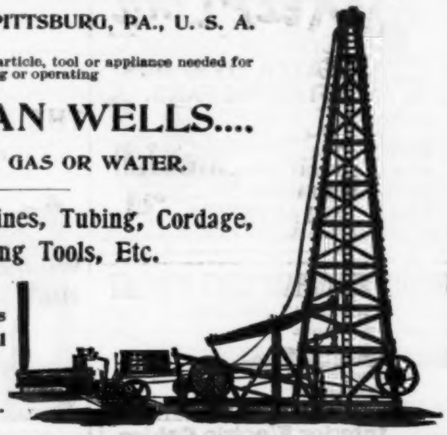

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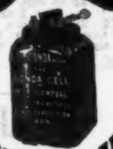

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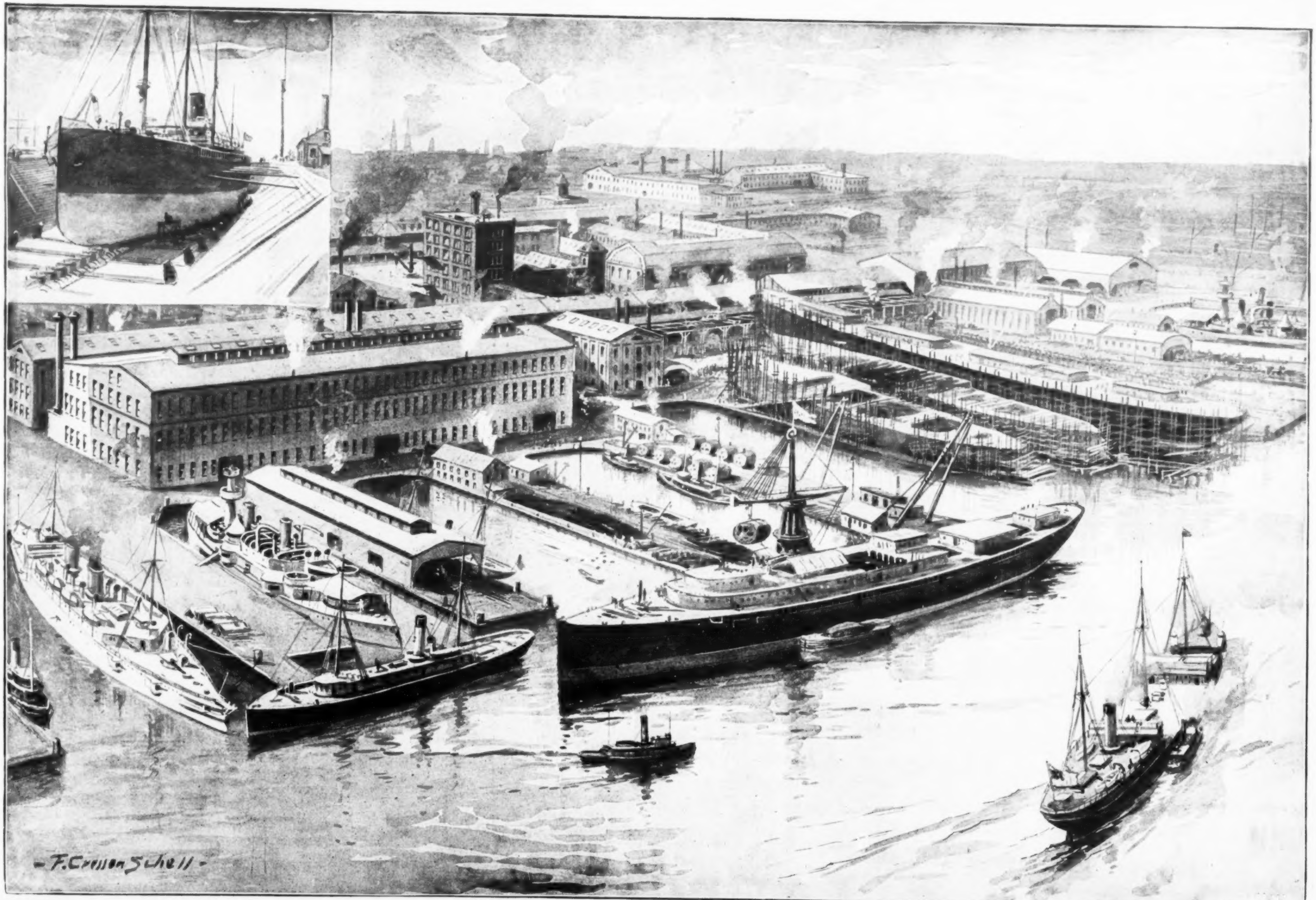

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